TM 9-1651

WAR DEPARTMENT

TECHNICAL MANUAL

UNIVERSITY OF CALIFORNIA
APR 25 1947
ORDNANCE MAINTENANCE

DATA TRANSMISSION SYSTEM, M3

JANUARY 25, 1942

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TECHNICAL MANUAL

DATA TRANSMISSION SYSTEM, M3

CHANGES No. 1

WAR DEPARTMENT,
WASHINGTON, January 8, 1943

TM 9–1651, January 25, 1942, is changed as follows:

26. Lubrication (superseded).—*a. Lubrication chart.*

Part	Frequency	Lubricant	Quantity and application
A-c generator	200 hours' operation.	Grease, lubricating, special (grease, special, low temperature).	One turn of grease cup cap, each bearing (front bearing is greased through ⅜-inch pipe between engine and generator; rear bearing through hole in bearing cap). Keep grease cups filled.
Water pump	50 hours' operation.	Grease, water pump.	One turn of grease cup cap. Keep grease cup filled.
Oil filter	150 hours' operation; oftener if oil becomes dirty.	----------	Renew refill cartridge.
Crankcase	50 hours' operation.	Oil, engine (See *b* below).	Drain and refill through breather tube as required to maintain level at least three-fourths full on bayonet gage; capacity 2 quarts.
Fan	-----do-----	-----do-----	Remove plug in hub. Fill until oil drips from shaft.
Starter	-----do-----	-----do-----	Few drops in oil hole.
Charging generator.	-----do-----	-----do-----	Eight to ten drops in oil cup at each end.
Distributor	-----do-----	-----do-----	Few drops in oiler.
Breaker mechanism.	-----do-----	Grease, water pump.	Wipe breaker cam lightly with grease.
Air filter	Once a day in dusty conditions to once a week where little dust is encountered. At least every time crankcase oil is changed. (See par. 25*b*(9).)	Oil, engine	Remove oil cup; empty and refill with fresh oil.

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Part	Frequency	Lubricant	Quantity and application
Governor linkage.	Occasionally	Oil, engine	Few drops on joints.
Commutators and slip rings.	Do not lubricate under any circumstances.		
Automatic choke.	Do not lubricate under any circumstances.		
Data indicators.	Occasionally	Oil, lubricating, for aircraft instruments and machine guns.	Few drops on gear trains and points where shafts enter housings. (Repeaters are not to be lubricated.)
Radial ball bearings, journal bearings, and all other sliding surfaces of the indicators.	When assembling.	Grease, lubricating, special (grease, special, low temperature).	Apply a thin coat of grease, preferably with brush.

b. Crankcase oil.—Use oil, engine, SAE 30, where the prevailing temperature range is above 32° F., and oil, engine, SAE 10, where the prevailing temperature range is between 32° F. and 0° F. Below 0° F., the procedure below should be followed to provide the engine with properly diluted engine oil for cold starting:

(1) With the oil level at "Full" mark and while engine is stopped, add a quantity of gasoline or dry-cleaning solvent equal to 20 percent (one-fifth) of the normal crankcase capacity.

(2) Run engine 5 to 10 minutes to mix oil and diluent thoroughly, then stop engine.

(3) After stopping, note level of crankcase oil on oil level gage stick. Level will be above normal "Full" mark. It is advisable to mark this increased level on the gage for future reference.

(4) At the end of each operating period, check oil level with engine stopped.

(5) If oil level is below normal "Full" mark on gage, add necessary quantity of oil, engine, SAE 10 (undiluted) to bring level up to "Full" mark. Then add the necessary quantity of gasoline or dry-cleaning solvent to raise level to the mark recorded in (3) above.

(6) If oil level is at or above normal "Full" mark on gage, add enough gasoline or dry-cleaning solvent to raise level to mark recorded in (3) above.

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(7) After steps (5) or (6), run engine 5 to 10 minutes to mix oil and diluent thoroughly.

[A. G. 062.11 (10-1-42).] (C 1, Jan. 8, 1943.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:
J. A. ULIO,
Major General,
The Adjutant General.

U. S. GOVERNMENT PRINTING OFFICE: 1942

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TECHNICAL MANUAL)
No. 9-1651)

WAR DEPARTMENT,
Washington, January 25, 1942.

ORDNANCE MAINTENANCE

DATA TRANSMISSION SYSTEM, M3

Prepared under direction of the
Chief of Ordnance

		Paragraphs
SECTION I.	General	1-3
II.	Description	4-14
III.	Operation	15-20
IV.	Inspection	21
V.	Maintenance and repair	22-23
VI.	Care and preservation	24-26
VII.	References	27-28
		Pages
INDEX		72-74

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SECTION I

GENERAL

	Paragraph
Purpose	1
Scope	2
References	3

1. PURPOSE. - This manual is published primarily for the information and guidance of Ordnance maintenance personnel.

2. SCOPE. - This manual supplements the technical manuals prepared for the using arm. It contains general descriptive matter and detailed instructions for maintenance and repair of the equipment by Ordnance personnel. Figures which accompany the text show the placement and method of fastening of each of the component parts of the equipment.

3. REFERENCES. - Section VII at the end of this manual lists all Standard Nomenclature Lists and other publications pertaining to this equipment.

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SECTION II

DESCRIPTION

	Paragraph
General	4
Components	5
Synchronous transmitters and repeaters	6
Main junction box	7
Receptacle box, 18 and 19-pole	8
Distribution box	9
Gun junction box	10
Azimuth and elevation indicator, M3	11
Fuze indicator, M3	12
Cable assemblies	13
Generating unit, M3	14

4. GENERAL. - a. The data transmission system, M3, is used with mobile antiaircraft artillery to transmit firing data continuously and instantaneously from remotely located fire control instruments to follow-the-pointer indicators on some 3-inch antiaircraft gun mounts.

b. The data transmission system can be used with either the AA director, M3, or the AA director, M4, without change of electrical connections or plug-and-receptacle assemblies.

c. This system can also be used with the on-carriage wiring components of data transmission system, T8E3, if cable receptacles are changed and proper electrical connections are made.

d. Instruments connected to the data transmission system include a director and height finder. These are described in separate technical manuals.

e. For general arrangement of the data transmission system, see Figure 1.

5. COMPONENTS. - a. A gasoline driven, electric generating unit provides the necessary power for the system. Two units are provided with each data transmission system. One unit is a standby to be used as an emergency source of power in case of the failure of the one in use.

b. On-carriage units include the azimuth indicator, M3, elevation indicator, M3, and fuze indicator, M3. These are connected through the gun junction box and distribution box to the receptacle box on the gun carriage.

c. The main junction box connects the director and power plant to the guns by cable and plug assemblies.

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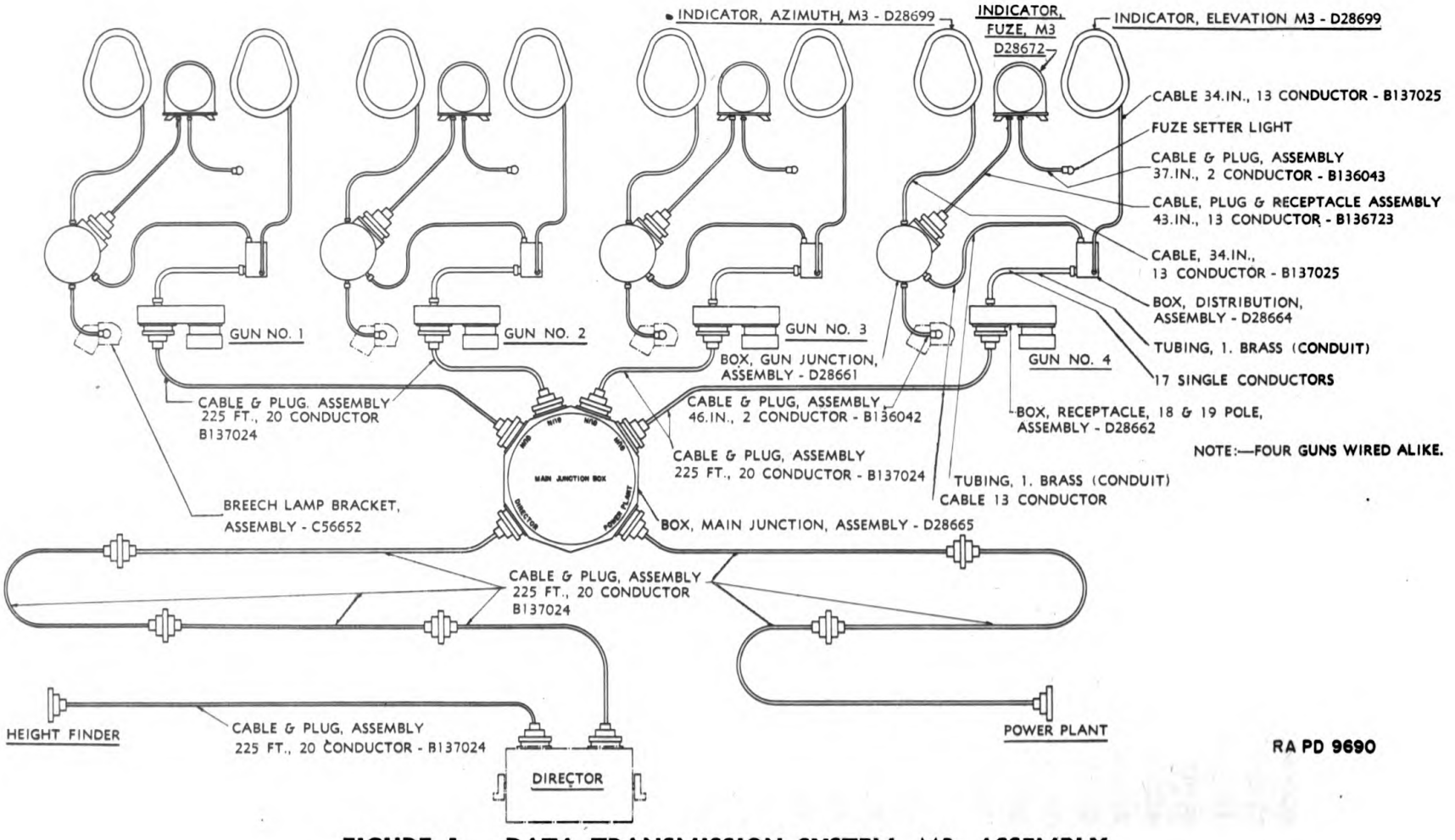

FIGURE 1 — DATA TRANSMISSION SYSTEM, M3 - ASSEMBLY

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d. A cable and plug assembly joins the height finder to the director.

6. SYNCHRONOUS TRANSMITTERS AND REPEATERS. - a. Operation of the data transmission system, M3 is based on the use of self-synchronous transmitters and repeaters. For each element of data transmitted, an a-c synchronous transmitter, one or more a-c synchronous repeaters, and connecting wiring are provided. Transmitters and repeaters (Figure 2) are similar in appearance. They are also similar mechanically and electrically except that the transmitters are usually larger in size and do not ordinarily have the damping devices provided on all repeaters to eliminate mechanical oscillations.

b. A transmitter and single repeater with the necessary electrical connections are shown in Figure 3. Each unit is wound with a 2-terminal field winding and a 3-terminal armature winding. The armature winding is similar to a 3-phase, Y-connected winding being essentially three windings separated electrically by 120 degrees. On some units the field is on the stator and the armature is on the rotor as shown; on others the arrangement is reversed, the two arrangements operating interchangeably. The five terminals of the transmitter are connected to the corresponding terminals of the repeater, and the source of electrical power is connected to the field terminals common to both. Each transmitter or repeater acts simply as a transformer; all voltages and currents existing in the instrument are single-phase. When the field is energized, voltages are induced in the three windings of the armature. The magnitude of the voltage in each winding being dependent on the relative angular position of the armature with respect to the field. At any angular position, the combination of voltages induced is peculiar to that position.

c. When the connected transmitter and repeater armatures are in the same relative angular position with respect to their fields, the voltage across each corresponding pair of armature terminals is the same and no current flows in the armature circuit. No torque is developed, and there is therefore no tendency to move from the position occupied. When this condition is obtained, the transmitter and repeater are said to be "in synchronism" or "synchronized".

d. If the transmitter armature is then turned to a new position, the armature voltages are changed. The difference in voltage between transmitter and repeater armature terminals will

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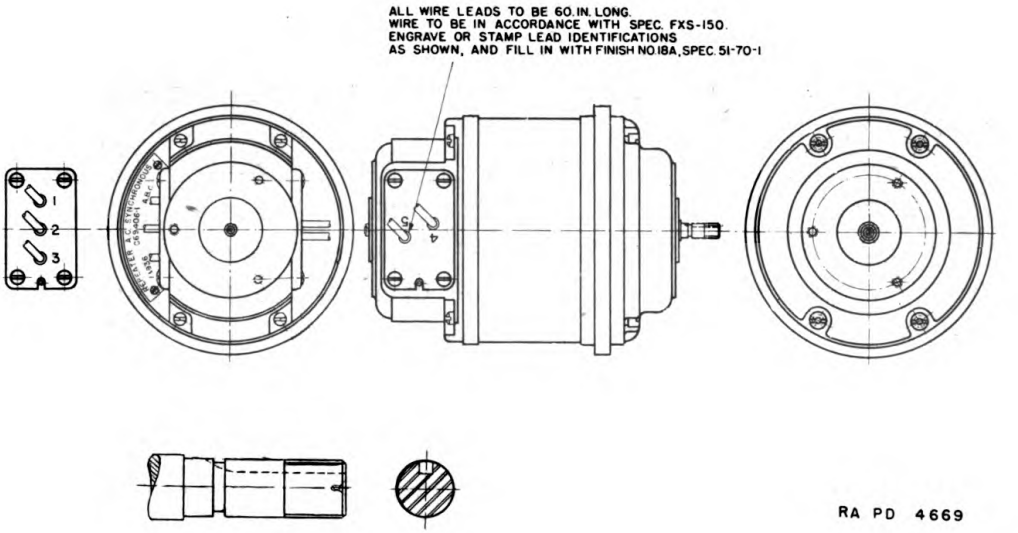

FIGURE 2 — A-C SYNCHRONOUS REPEATER - ASSEMBLY

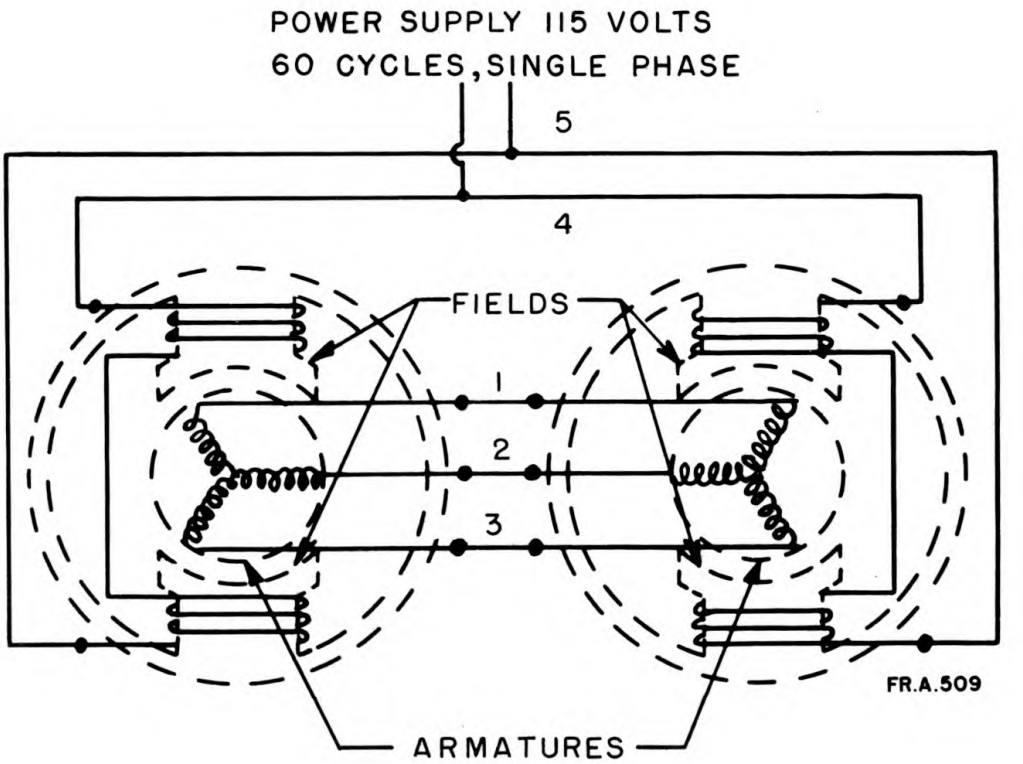

FIGURE 3 — SYNCHRONOUS TRANSMITTER AND REPEATER

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cause currents to flow which react with the magnetic field created by the field windings to develop torques in such direction that they tend to bring both armatures to the same relative positions. The repeater, if free to move, is thus brought toward the synchronized position. A damping device in each repeater prevents prolonged oscillation of the repeater about its final position.

e. The repeater will also synchronize with the transmitter when power is applied, regardless of their relative positions prior to application of power. This feature results in the system being termed "self-synchronous" and makes it superior to other electrical data transmission systems.

f. For transmission of the same data to different points, repeaters connected in multiple to an appropriately designed transmitter are employed.

g. Each transmitter is capable of controlling its receiver motor within a precision of $1/2^{\circ}$ under static conditions. At a speed of 1 rpm the required accuracy is $3/4^{\circ}$. Where the required accuracy is greater than that possible with a single transmitter the data to be transmitted are broken up into two parts, the "coarse" and the "fine", these parts being transmitted and received by separate transmitters and receivers.

h. For accurate transmission of data, the three armature interconnections must be of low resistance and the individual resistances must be equal; the cables provided are properly designed to meet this condition. It is necessary that field voltages at the transmitter and repeater be equalized; separate terminals are therefore provided on the generating unit whereby a higher voltage is made available for the distant units to compensate for voltage drop in the line.

i. The system cannot be used to transmit data accurately when the repeaters carry mechanical load. Each repeater is therefore used with a follow-the-pointer drive for the application of data. Each repeater carries an electrically driven index. A mechanically driven index which is connected to the element to be positioned, is brought into alinement with the electrically driven index by means of a handwheel or other drive.

j. The synchronous repeaters may become damaged by imparting to them a high initial speed, thus causing them to run as motors. This condition may occur if a damping device becomes ineffective or the unit is manually spun or forced from synchronism and allowed to snap back.

k. The units will withstand the continuous heating caused

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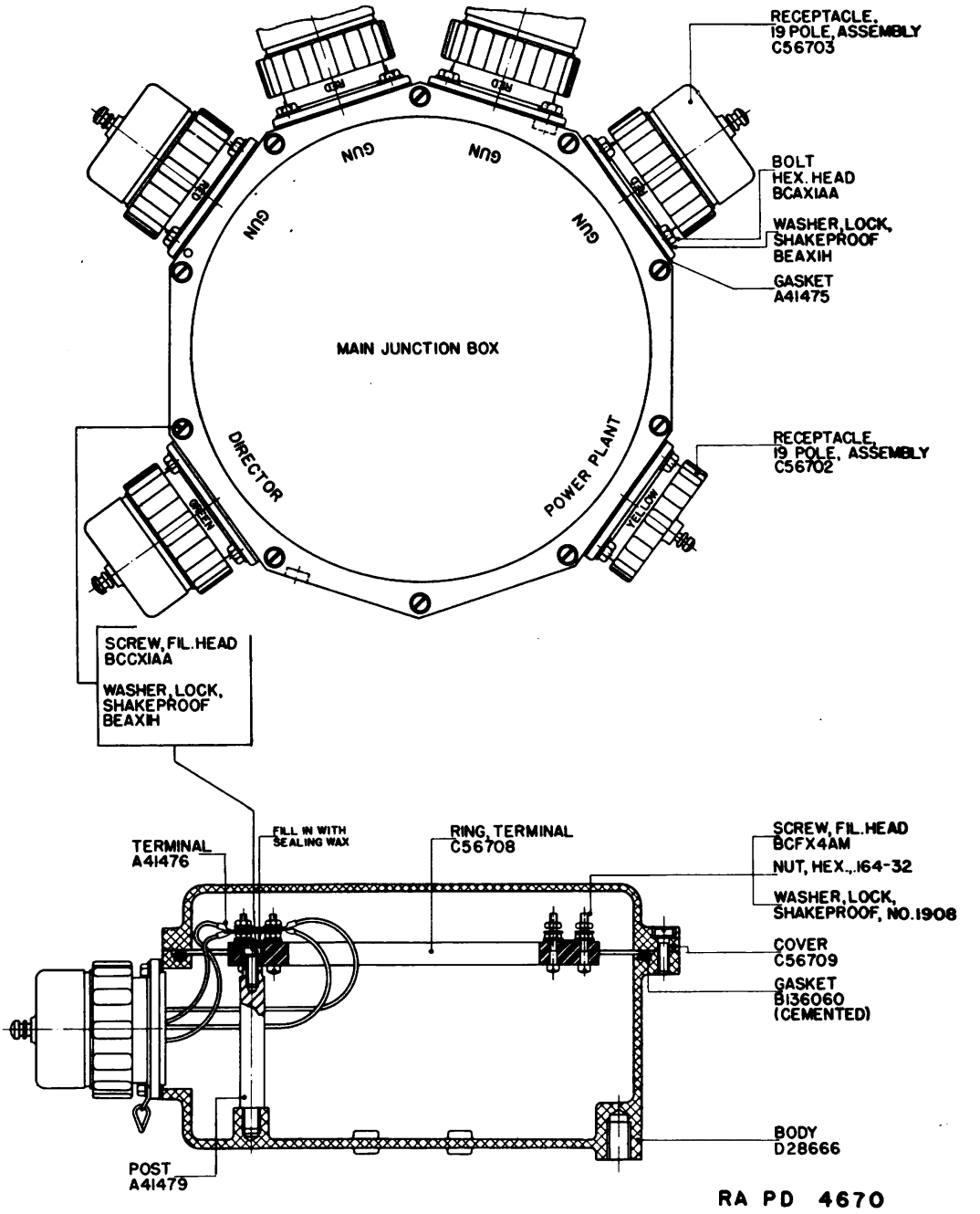

FIGURE 4 — MAIN JUNCTION BOX - ASSEMBLY

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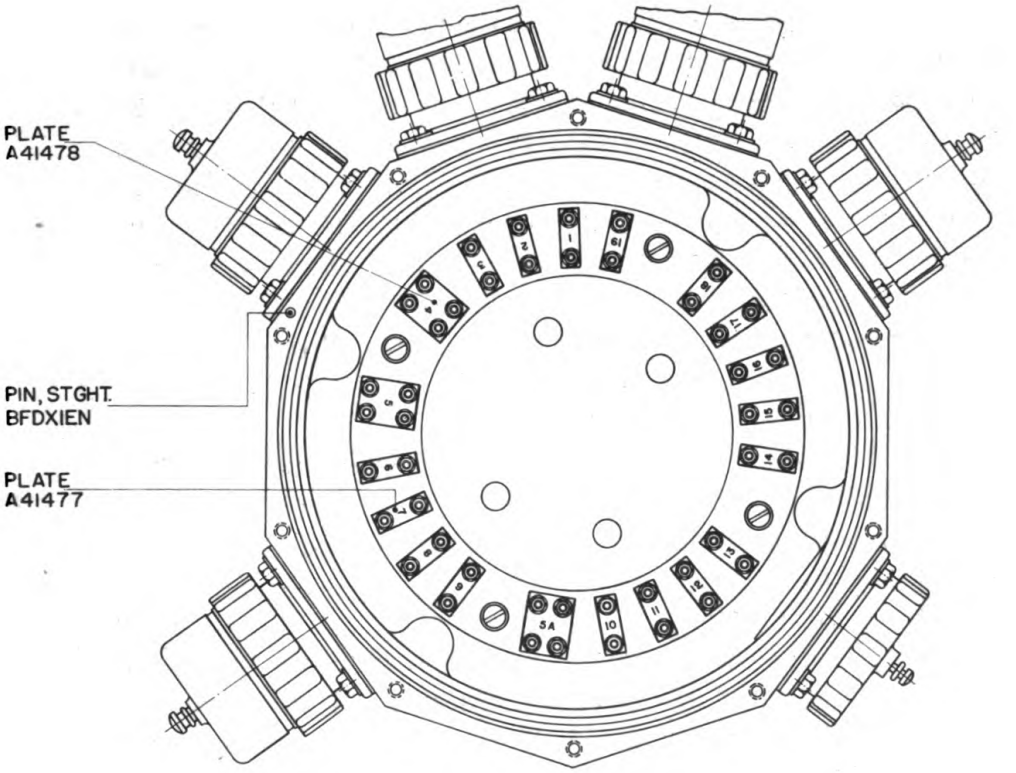

FIGURE 5 — MAIN JUNCTION BOX - COVER REMOVED

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by normal use. However, excessive heating and damage may result if a displacement angle of 25° or more exists for a considerable period.

7. MAIN JUNCTION BOX. - a. The main junction box assembly (D28665, Figures 4 and 5) includes a decagonal shaped cast aluminum body (D28666). A cover (C56709) seals the box, and when removed, offers access to the internal wiring of the junction box for inspection or repair. The box is portable and may be placed in any convenient position to accommodate the arrangement of the guns and the director. Rubber gaskets under the junction box cover and under the receptacles make the junction box watertight.

b. Six receptacle assemblies are provided:

(1) One 19-pole receptacle assembly (C56702), painted yellow, connects to the power plant.

(2) One 19-pole receptacle assembly (C56703), painted green, connects to the director.

(3) Four 19-pole receptacle assemblies (C56703), painted red, connect to the four guns.

c. The annular terminal ring (C56708), supported on four posts (A41479), contains contact plates and binding posts for electrical connections. See wiring, diagram (Figure 22).

8. RECEPTACLE BOX, 18 AND 19-POLE. - a. The receptacle box assembly (D28662, Figures 6 and 7) includes a rectangular cast aluminum body (D28537), mounted on a special bracket bolted to the front of the top carriage (Figure 12) of each gun. The box cover (B135650) and receptacle covers are provided with watertight rubber gaskets. For wiring see Figure 23.

b. The receptacle box assembly contains two banks of 10 terminals each, mounted on the box cover and connecting the gun cable (17 single conductors, brass conduit) with the 18 and 19-pole receptacles attached to the box.

c. The 19-pole receptacle assembly (C56702) is connected to the main junction box. The 18-pole receptacle accommodates the 18-pole plugs used on data transmission systems, M2, M2A1, and M2A2.

9. DISTRIBUTION BOX. - a. The distribution box assembly (D28664, Figure 8) consists of a rectangular cast aluminum body, which supports 3 outlet connections and a cover. The packing gland (Figure 9, Section B-B) accommodates the cable leading to the gun junction box. The second connector (CGB289 or equal) is for the conduit from the receptacle box. The third connector (CGB295 or equal) is for the cable (B137025) to the ele-

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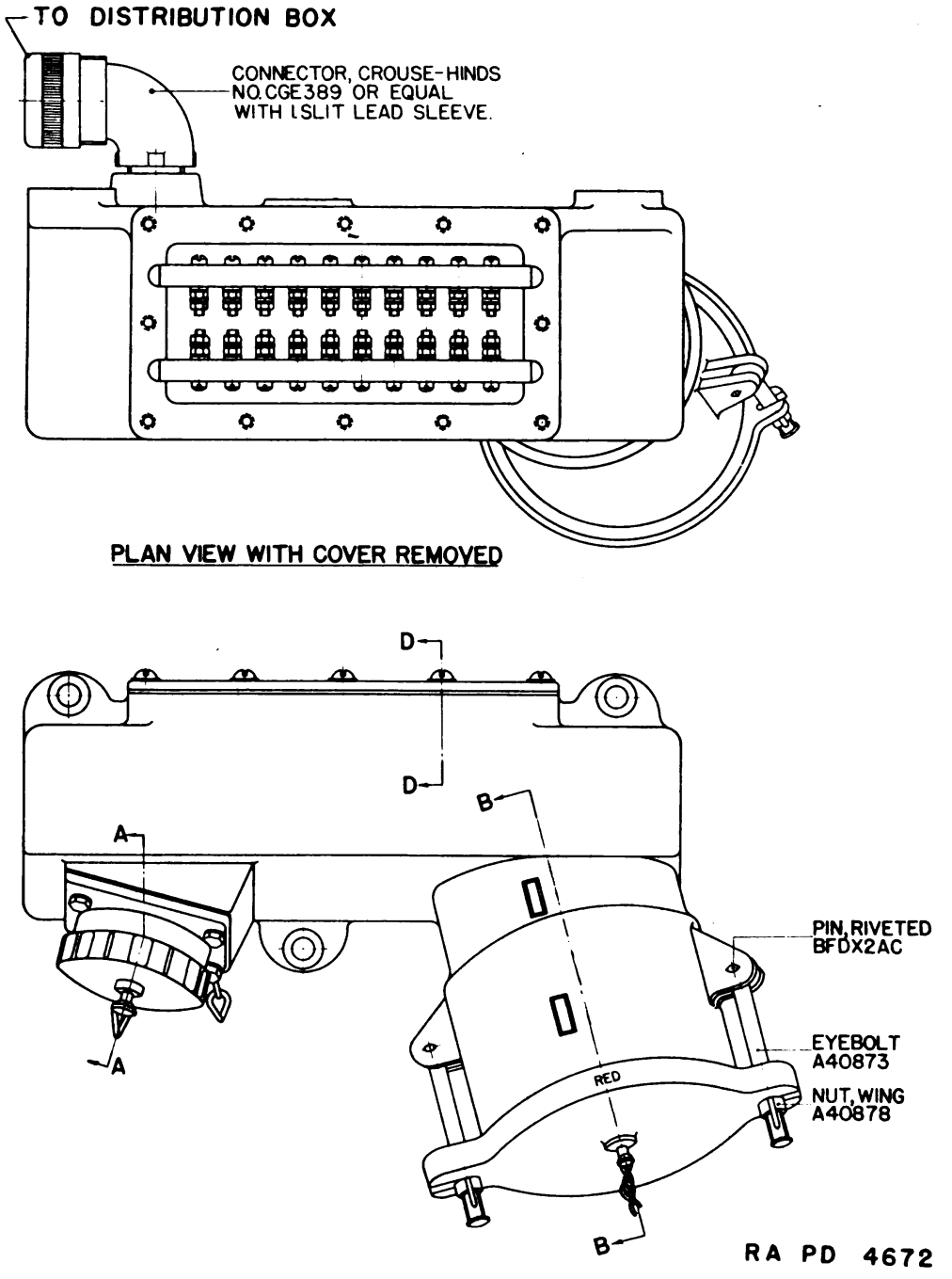

FIGURE 6 — RECEPTACLE BOX, 18 AND 19 POLE - ASSEMBLY

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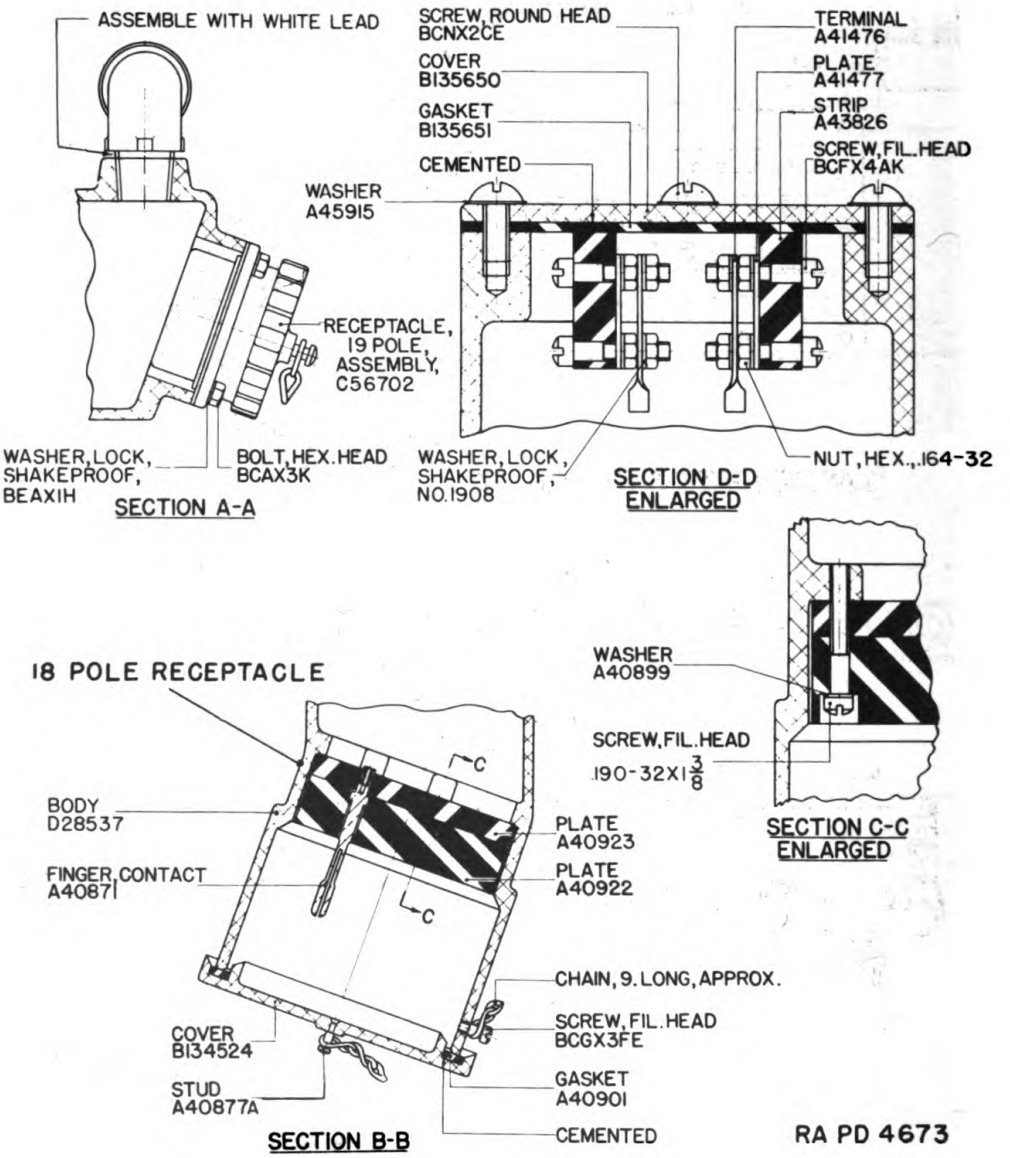

FIGURE 7 — RECEPTACLE BOX, 18 AND 19 POLE

SECTIONED VIEWS

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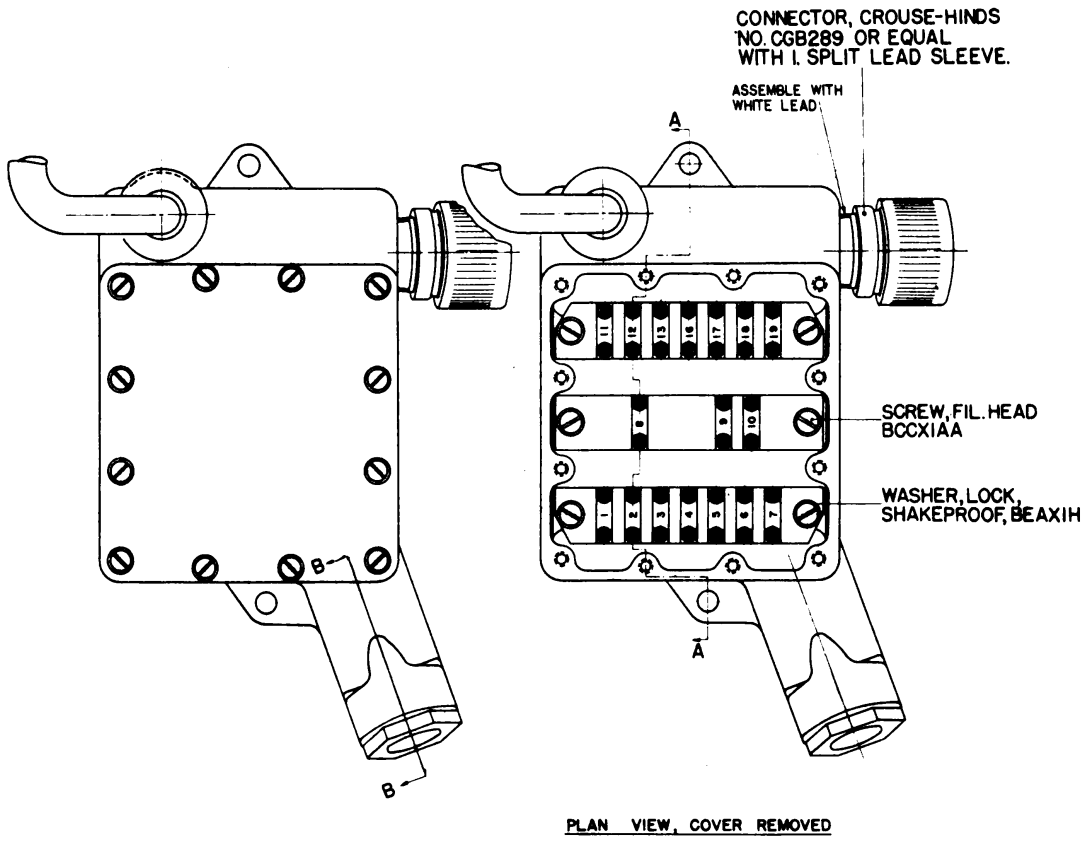

FIGURE 8 — DISTRIBUTION BOX - ASSEMBLY

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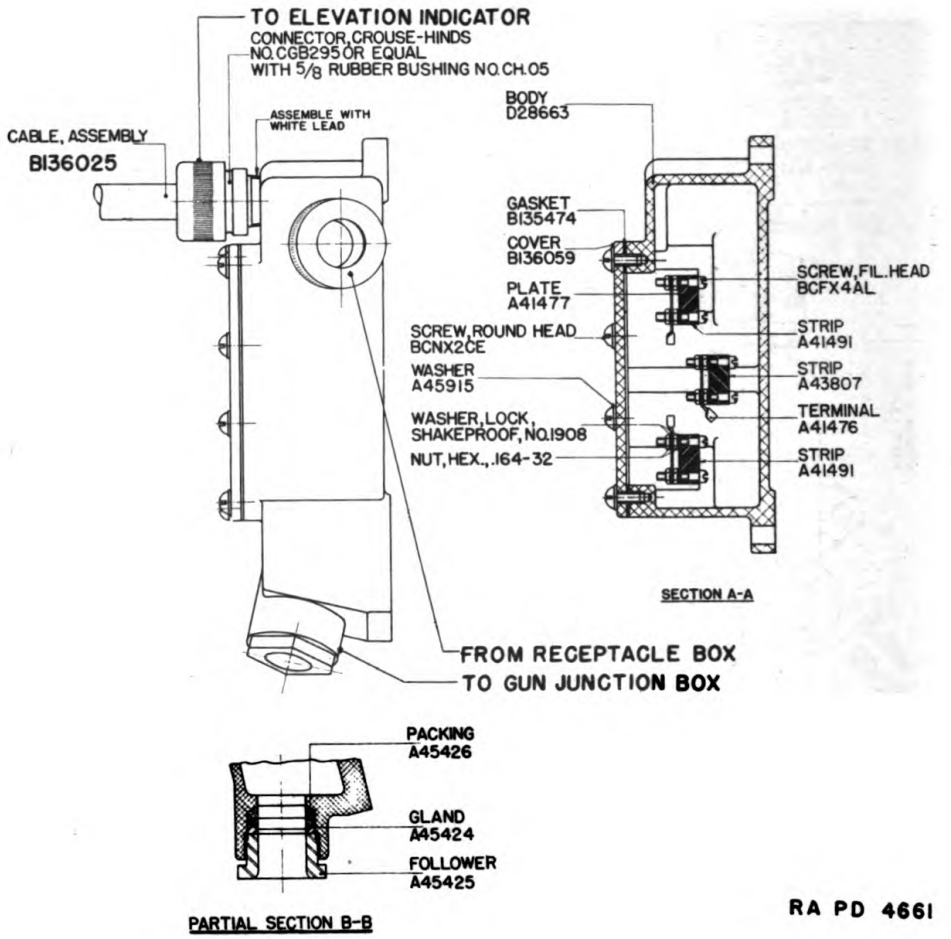

FIGURE 9 — DISTRIBUTION BOX - END ELEVATION AND SECTIONED VIEWS

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vation indicator, M3.

b. The three terminal blocks provided in this box are wired in accordance with the wiring diagram (Figure 23). The terminal plates are marked to match the marked cable terminals.

c. The distribution box is watertight and is bolted to the top carriage of each gun.

10. GUN JUNCTION BOX. - a. The gun junction box assembly (D28661, Figures 10 and 11) consists of a cylindrical cast aluminum body (D28660) and a cover (A45422). Connections on the body include the 19-pole receptacle assembly (C56703) which leads to the fuze indicator, the packing gland (Figure 10, Section C-C) which accommodates the cable from the distribution box, the connector (CGB295 or equal) leading to the azimuth indicator, and the connector (CGB194 or equal) leading to the breech light. A covered socket receptacle assembly (B135614) accommodates a trouble light and cable.

b. The transformer (B134814) reduces the 115-volt line voltage to 6 volts for the lamps.

c. Two terminal blocks accommodate the electrical connections in accordance with the wiring diagram. Terminal plates and terminals are marked for identification. For wiring see Figure 23.

11. AZIMUTH AND ELEVATION INDICATORS, M3. - a. The azimuth indicator, M3, and elevation indicator, M3, (Figures 14 to 18) are identical follow-the-pointer instruments. Each consists primarily of one "coarse" repeater and one "fine" repeater electrically operated by the director. Each repeater has a set of concentric, graduated dials or pointer indexes. Operation of the gun controls activates mechanical drives which, in turn, rotate indexes and dials to match the data supplied by the director. The azimuth indicator and elevation indicator each has its entire mechanism inclosed in a watertight case provided with a nonshatterable glass window through which the scales and index pointers may be seen. The azimuth indicator is located on the left side of the gun mount, and the elevation indicator on the right. For wiring see Figure 23.

b. The "coarse" repeater (Figures 14 to 18) supports two concentric dials and drives the inner dial (A44264), which is graduated at 400 mil intervals from 0 to 6,400 mils. The outer dial, similarly graduated, and read against an index (A46477), is driven by a worm gear (B136685) geared to a worm (A46469, Figures 15 and 16). This drive is geared to the gun mount. Motion of the gun mount moves the outer dial. A knob (A46446,

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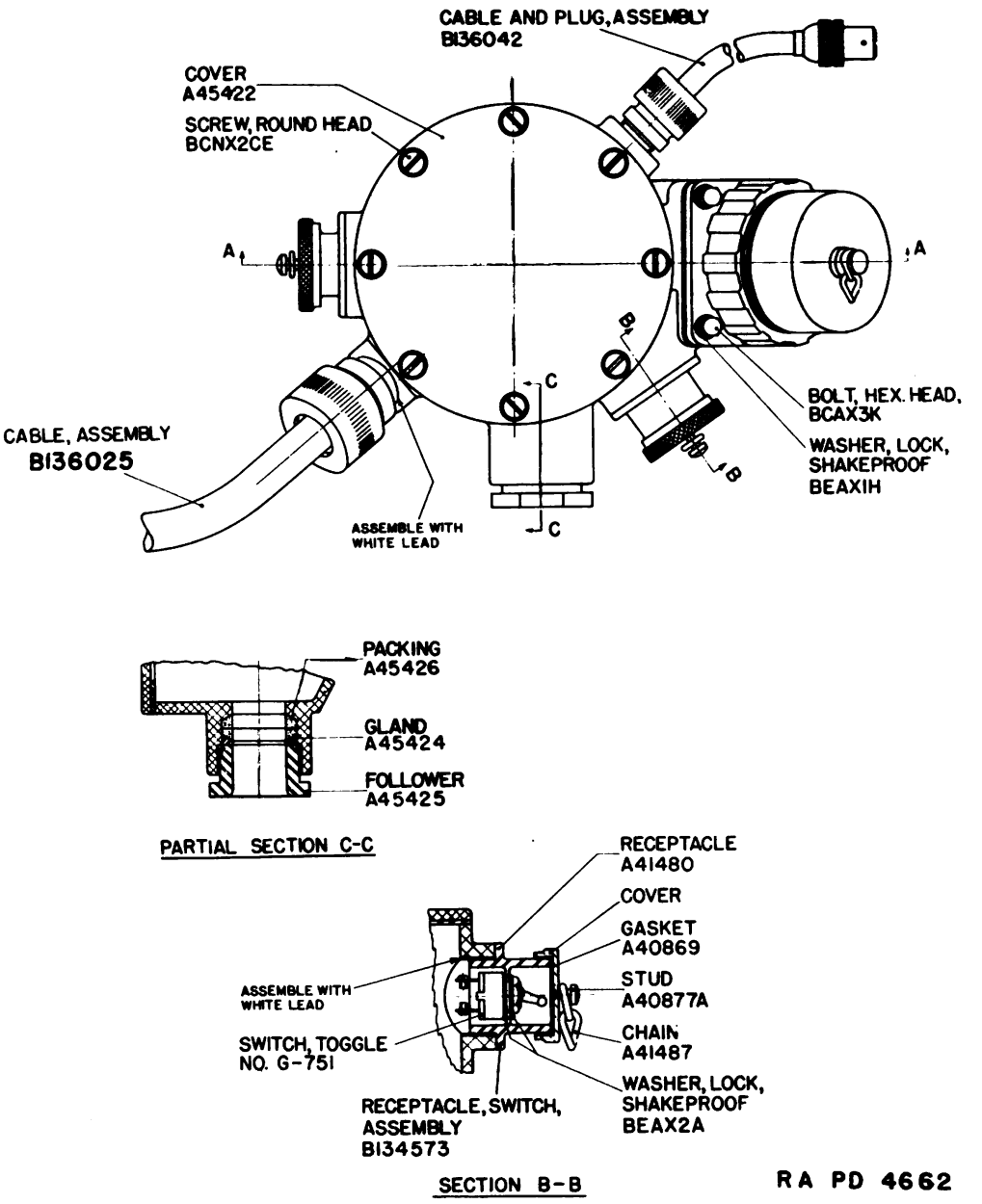

FIGURE 10 — GUN JUNCTION BOX - ASSEMBLY,

SECTIONS B-B AND C-C

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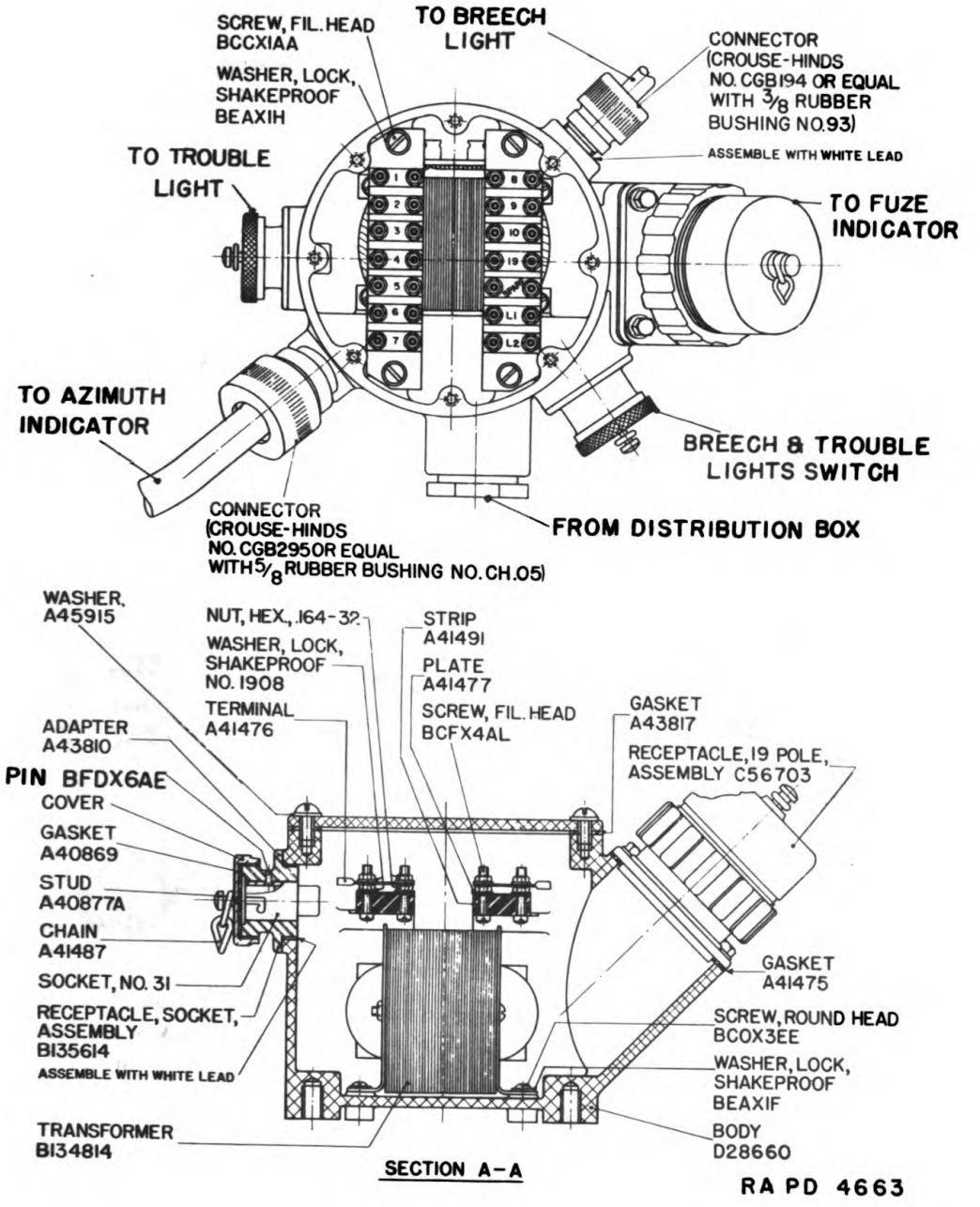

FIGURE 11 — GUN JUNCTION BOX - COVER REMOVED AND SECTION A-A

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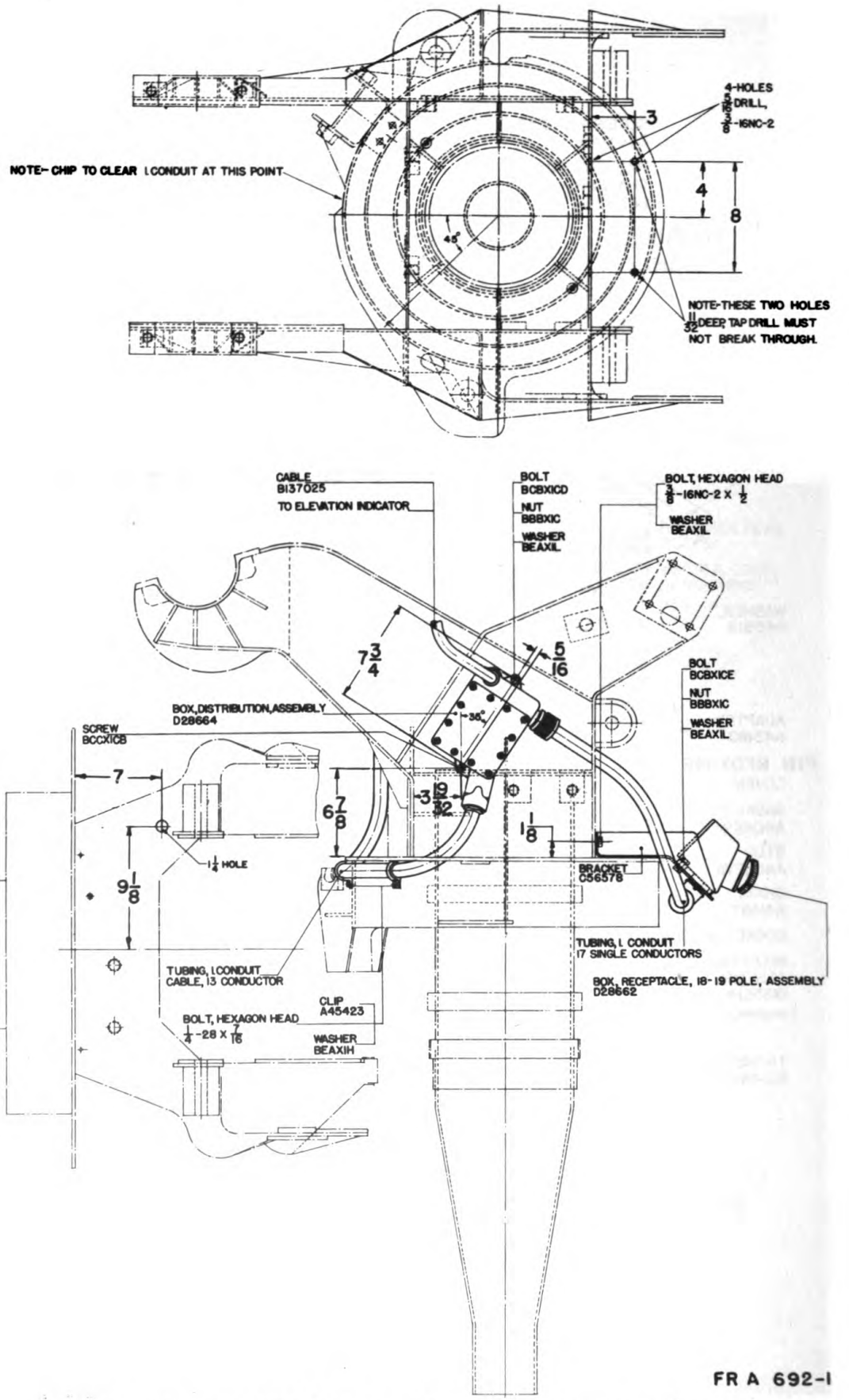

FIGURE 12 — ARRANGEMENT OF DISTRIBUTION BOX AND RECEPTACLE BOX ON TOP CARRIAGE

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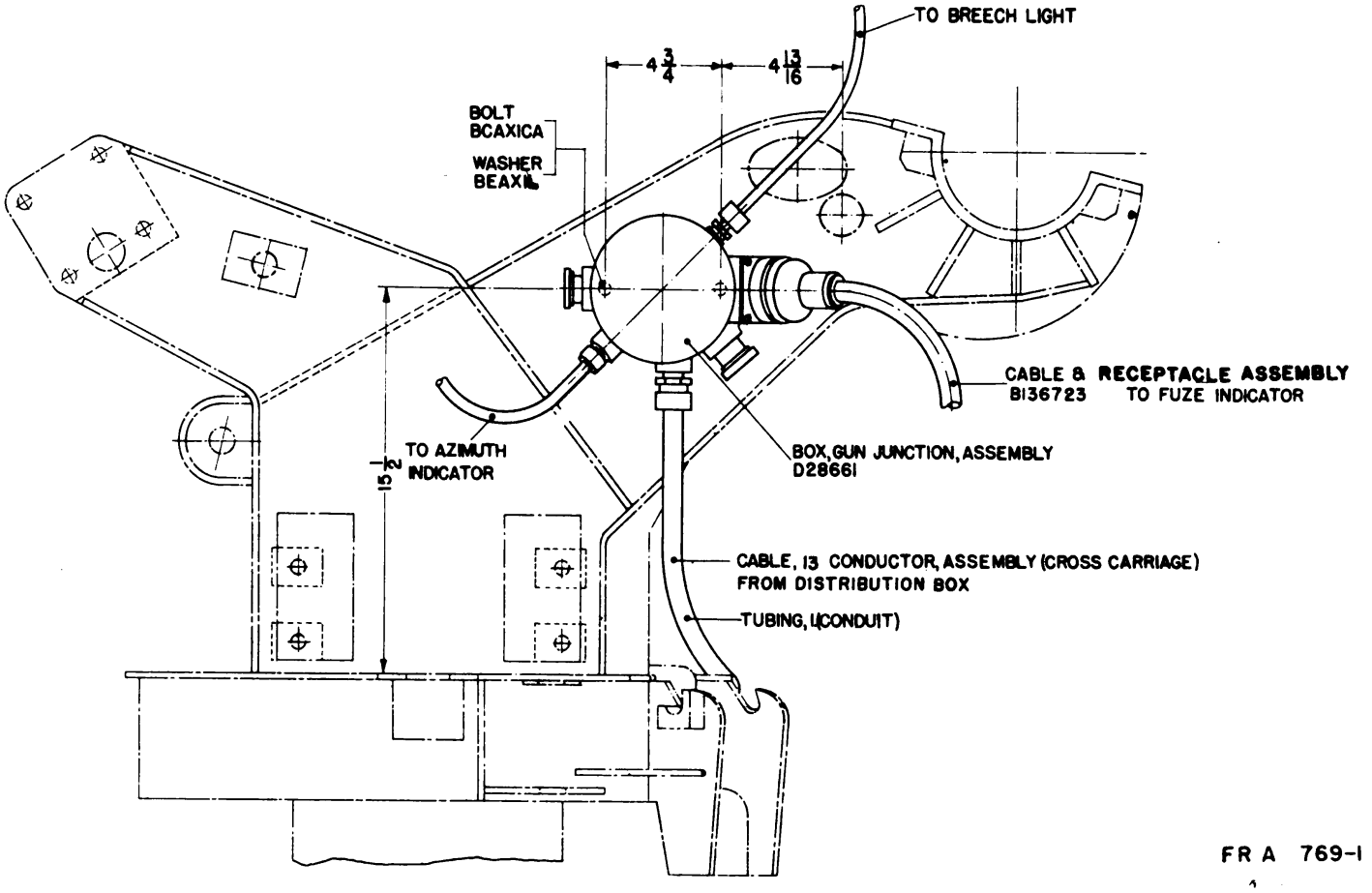

FIGURE 13 — ARRANGEMENT OF GUN JUNCTION BOX ON TOP CARRIAGE

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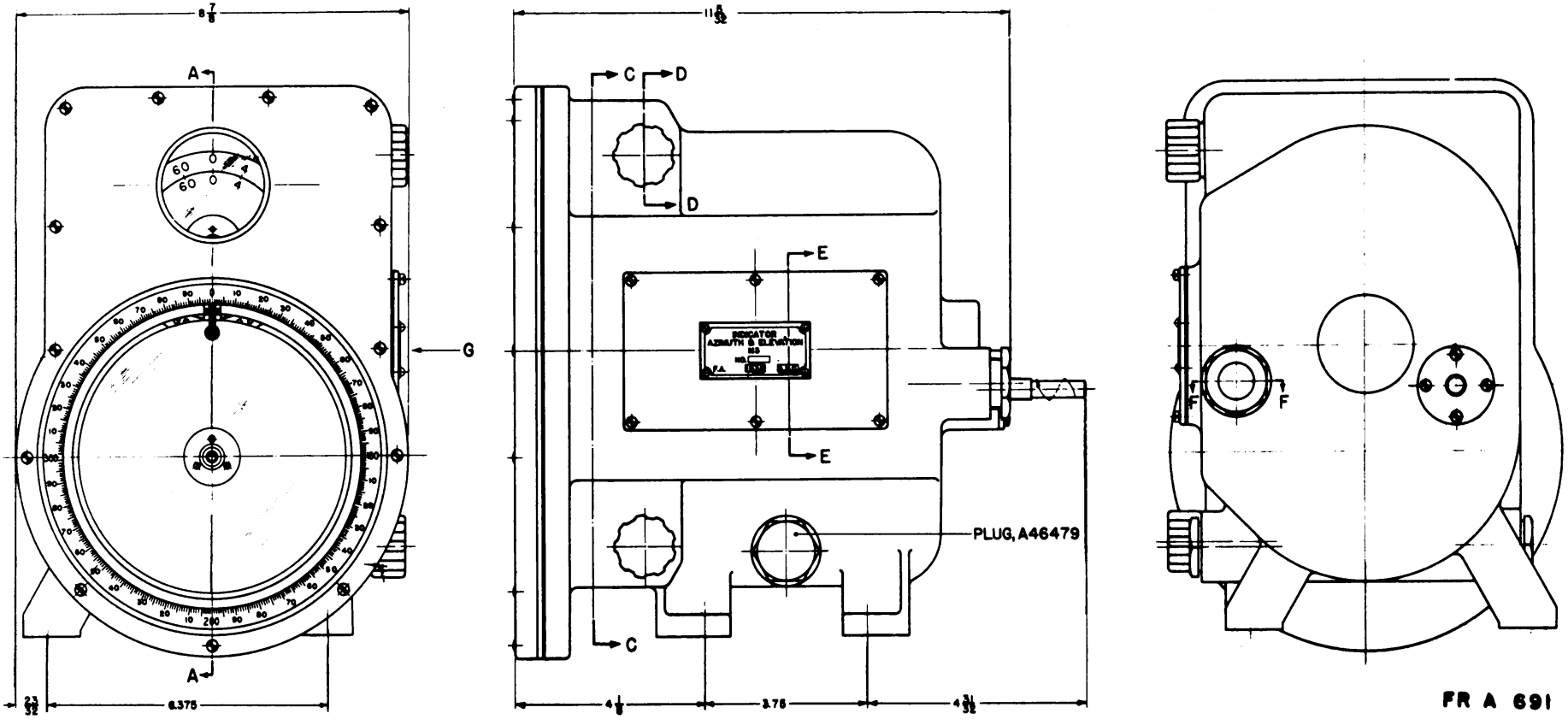

FIGURE 14 — AZIMUTH AND ELEVATION INDICATOR, M3 - ASSEMBLY

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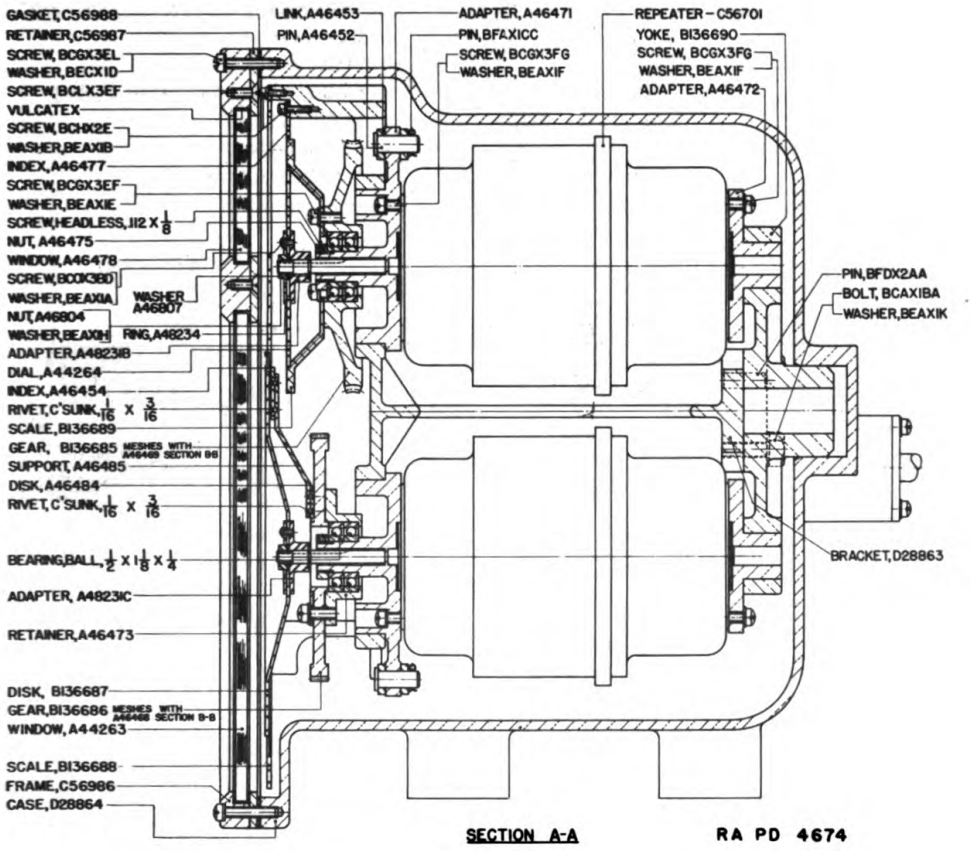

FIGURE 15 — AZIMUTH AND ELEVATION INDICATOR,

M3 - SECTION A-A

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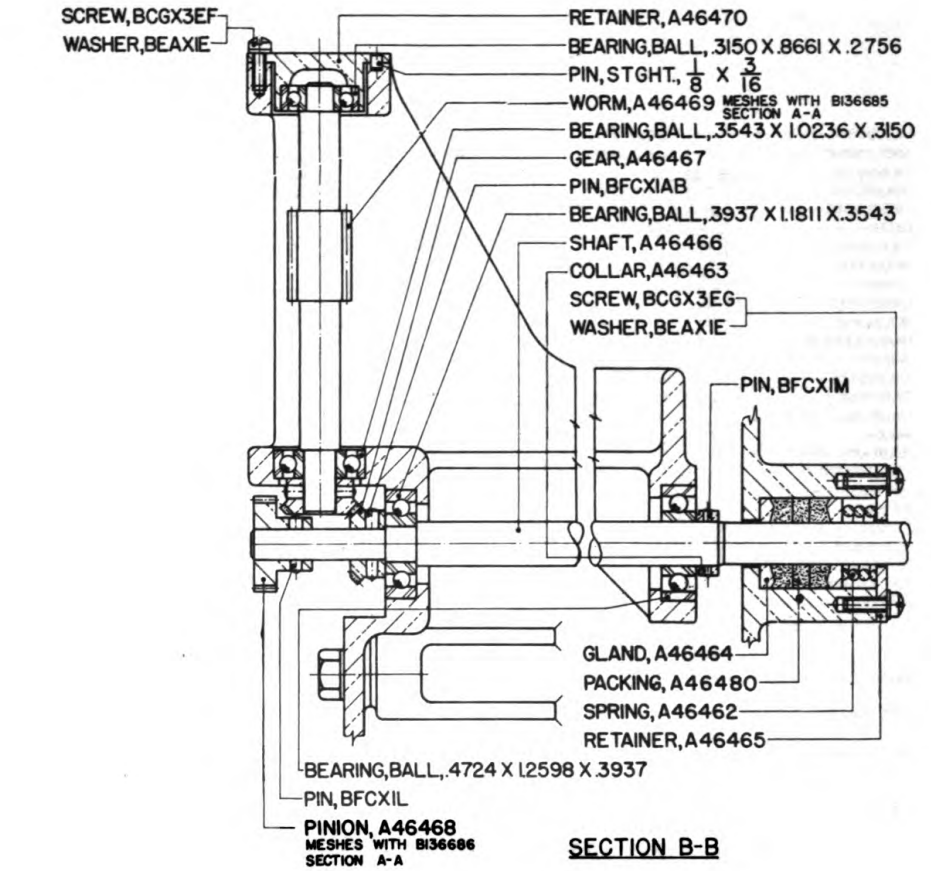
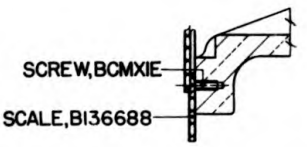


FIG. 17, SEC. C - C
LOCATES SEC. B - B



SECTION SHOWING RETAINING SCREW FOR SCALE

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FIGURE 16 — AZIMUTH AND ELEVATION INDICATOR, M3 - SECTION B-B

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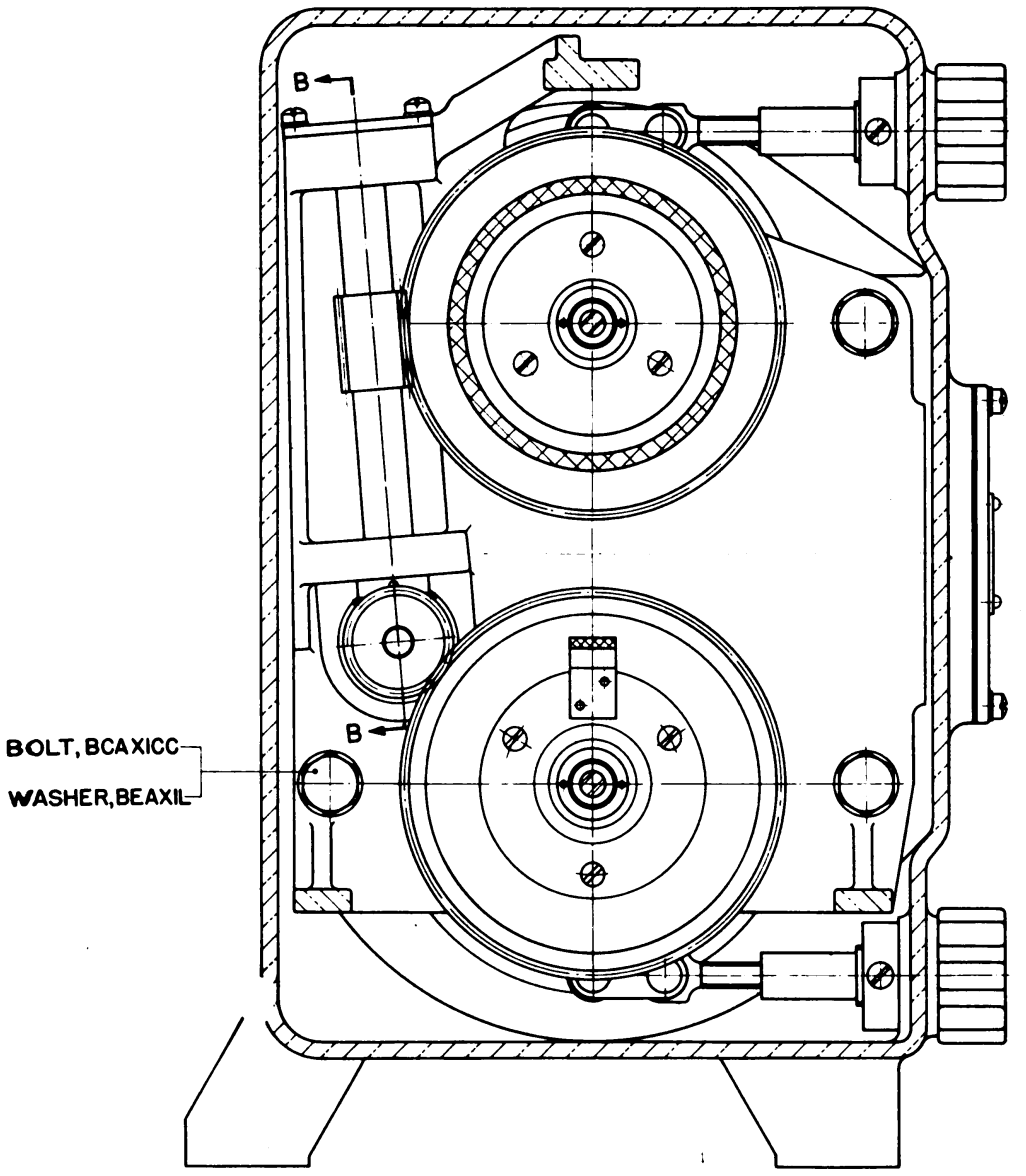

SECTION C-C RA PD 4676

FIGURE 17 — AZIMUTH AND ELEVATION INDICATOR, M3 - SECTION C-C

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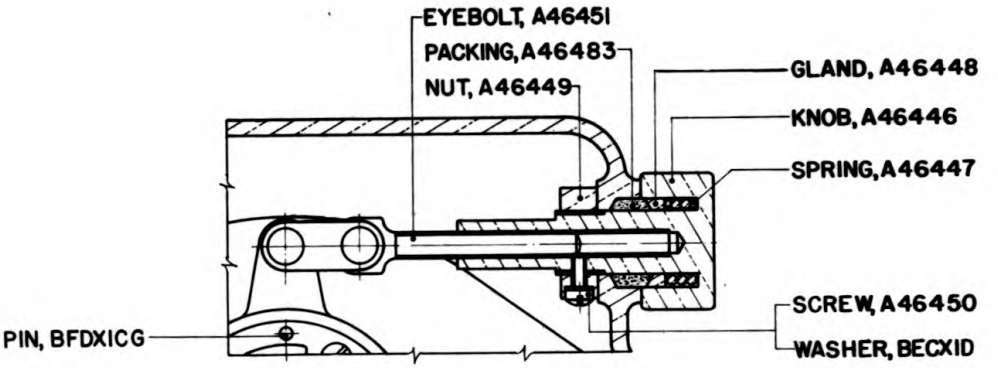
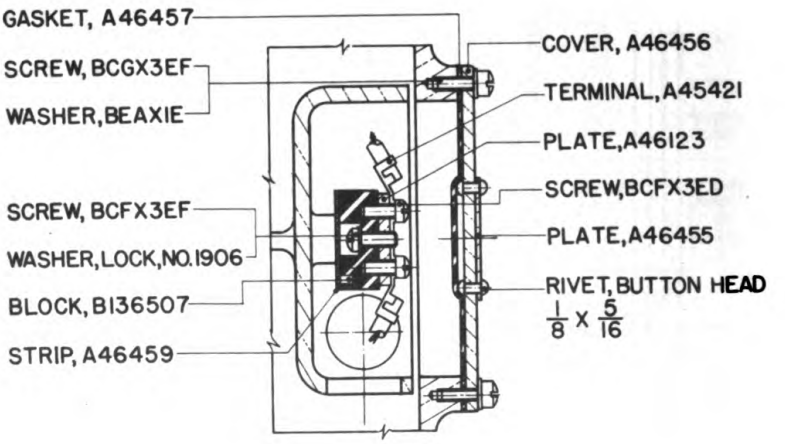
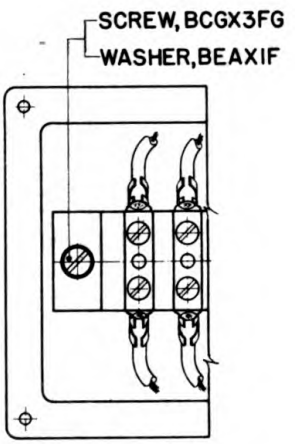


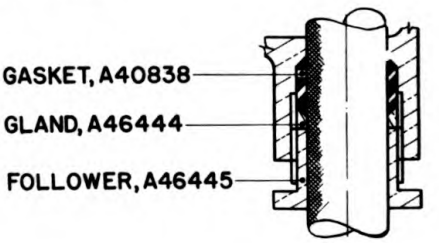
SECTION D-D



SECTION E-E



VIEW G WITH COVER REMOVED



SECTION F-F

RA PD 4677

FIGURE 18 — AZIMUTH AND ELEVATION INDICATOR, M3 - SECTIONED VIEWS

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Section D-D, Figure 18) permits rotation of the repeater through about 15° on either side of the zero position for orientation with the transmitters in the director. Rotation of the knob is still to avoid possibility of accidental shifting.

c. The lower or "fine" repeater supports two pointers which move concentrically, driving the inner pointer disk (B136687) on which is engraved an index. The outer index (A46454) is fastened to a gear (B136686) which meshes with another gear (A46468, Section B-B, Figure 16). This gear (A46468) is mounted on a shaft (A46466) and is geared to the same worm (A46469) as the worm gear which drives the outer dial of the "coarse" indicator. The stationary scale (B136688) is graduated at 2 mil intervals from 0 to 400 mils. A knob (A46446) permits rotation of the repeater through about 15° on either side of the zero position for orientation with the transmitters in the director. Rotation of the knob is stiff to avoid possibility of accidental shifting.

d. Both repeaters (Figures 15 and 16) are bolted at the shaft end to adapters (A46471), which are linked to the knobs (A46446). The adapters rotate in a bracket (D28863) on rotation of the knobs. The other ends of the repeaters are bolted to adapters (A46472) which float in a yoke (B136690). The yoke in turn has a stud which floats in a bored recess of the case (D28864). This type of construction insures alinement of dials and gears with respect to the shaft end plate of the repeater. Individual differences in over-all length of the repeaters, etc., are compensated for in this floating type of construction.

e. The "fine" dial pointer, its match-the-pointer index, and the graduations and numbers of the "coarse" dial and scale are filled with luminous paint.

f. All electrical leads are brought out to the terminal block (B136507, Figure 18, Section E-E, and Figure 23) which may be reached by removing the cover (A46456) to which the name plate is fastened.

12. FUZE INDICATOR, M3. - a. The fuze indicator, M3 (Figures 19 to 21) is essentially a repeater with two pointer indexes operating concentrically. The fuze indicator is bolted to the fuze setter. The inner pointer disk (A46425) turns with the repeater shaft when the repeater is activated by data electrically transmitted from the director. The outer pointer index (A46454) is mechanically connected by spiral miter gears and shafting to the fuze setter. The fuze setter is operated to follow the pointer of the fuze indicator. The entire mechanism

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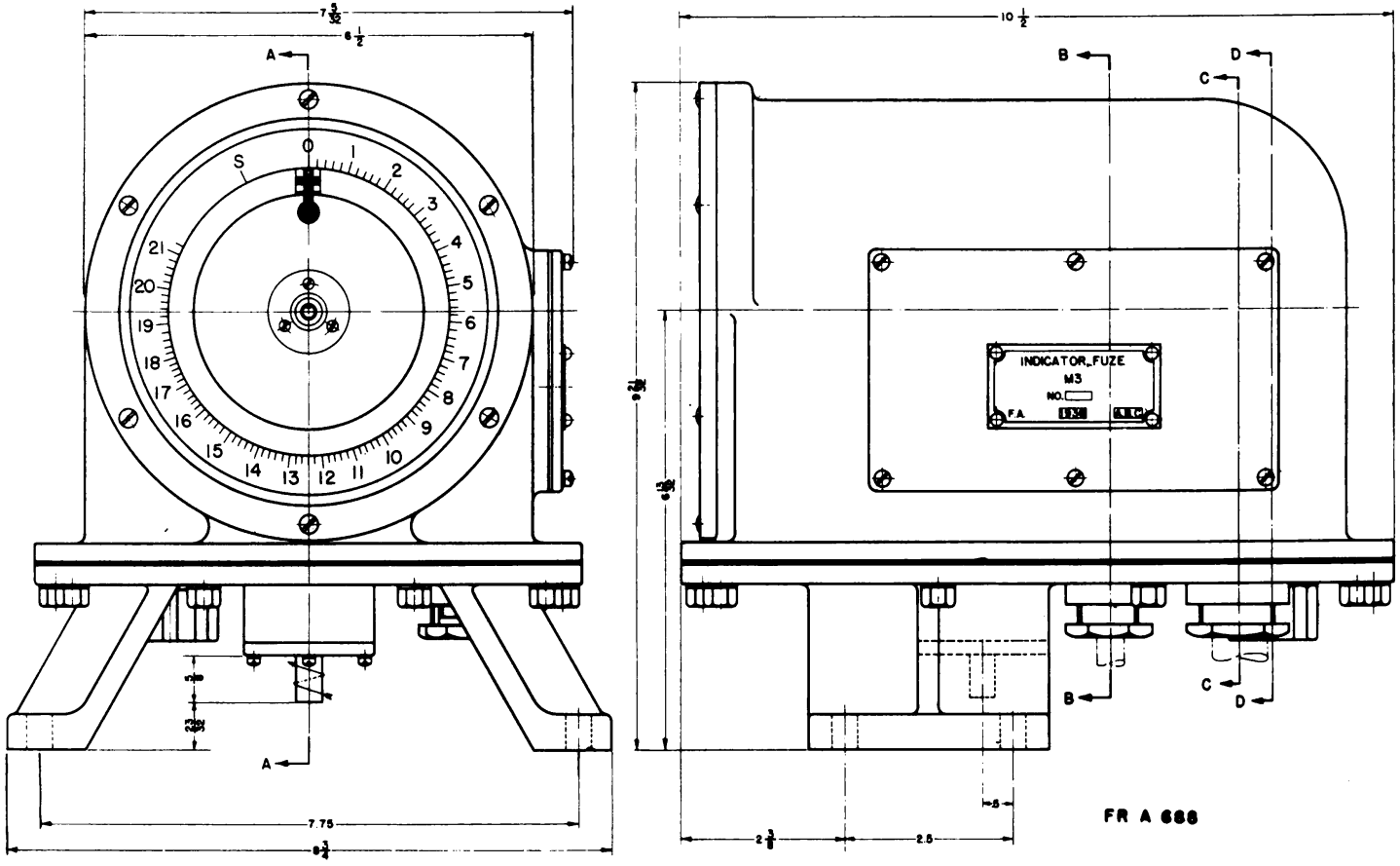

FIGURE 19 — FUZE INDICATOR, M3 - ASSEMBLY

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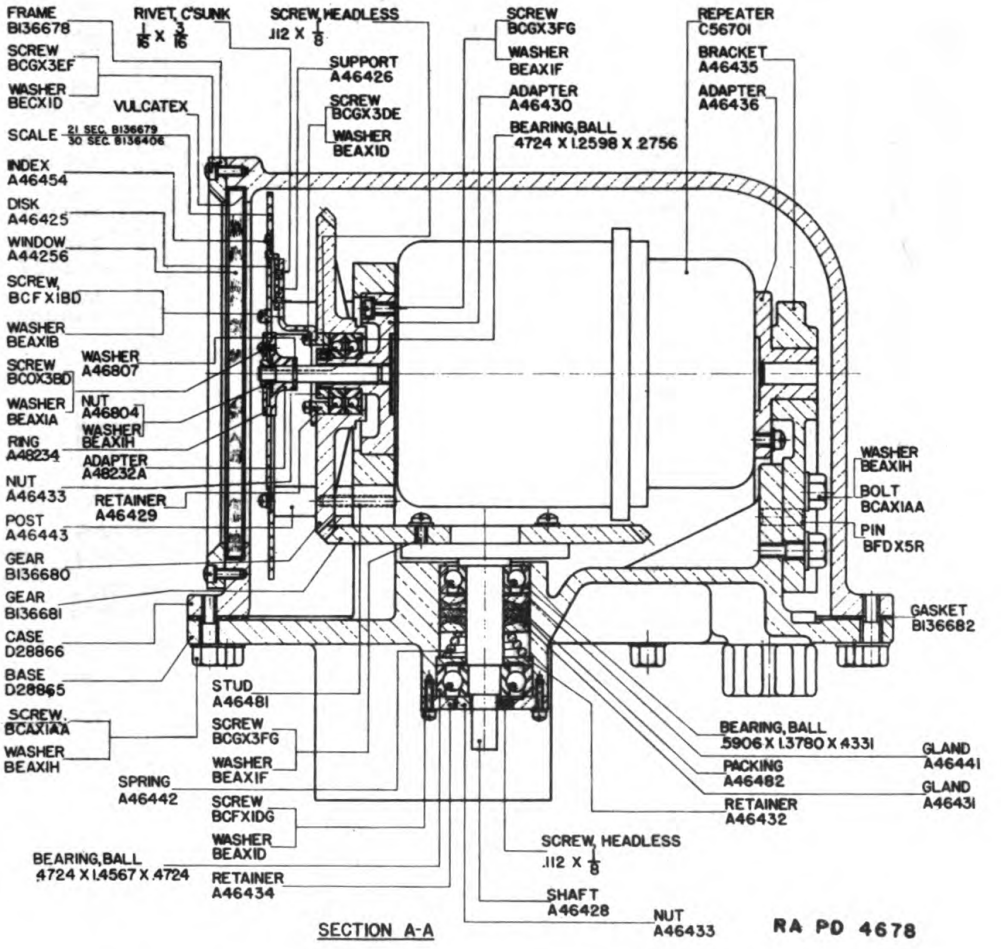

FIGURE 20 — FUZE INDICATOR, M3 - SECTION A-A

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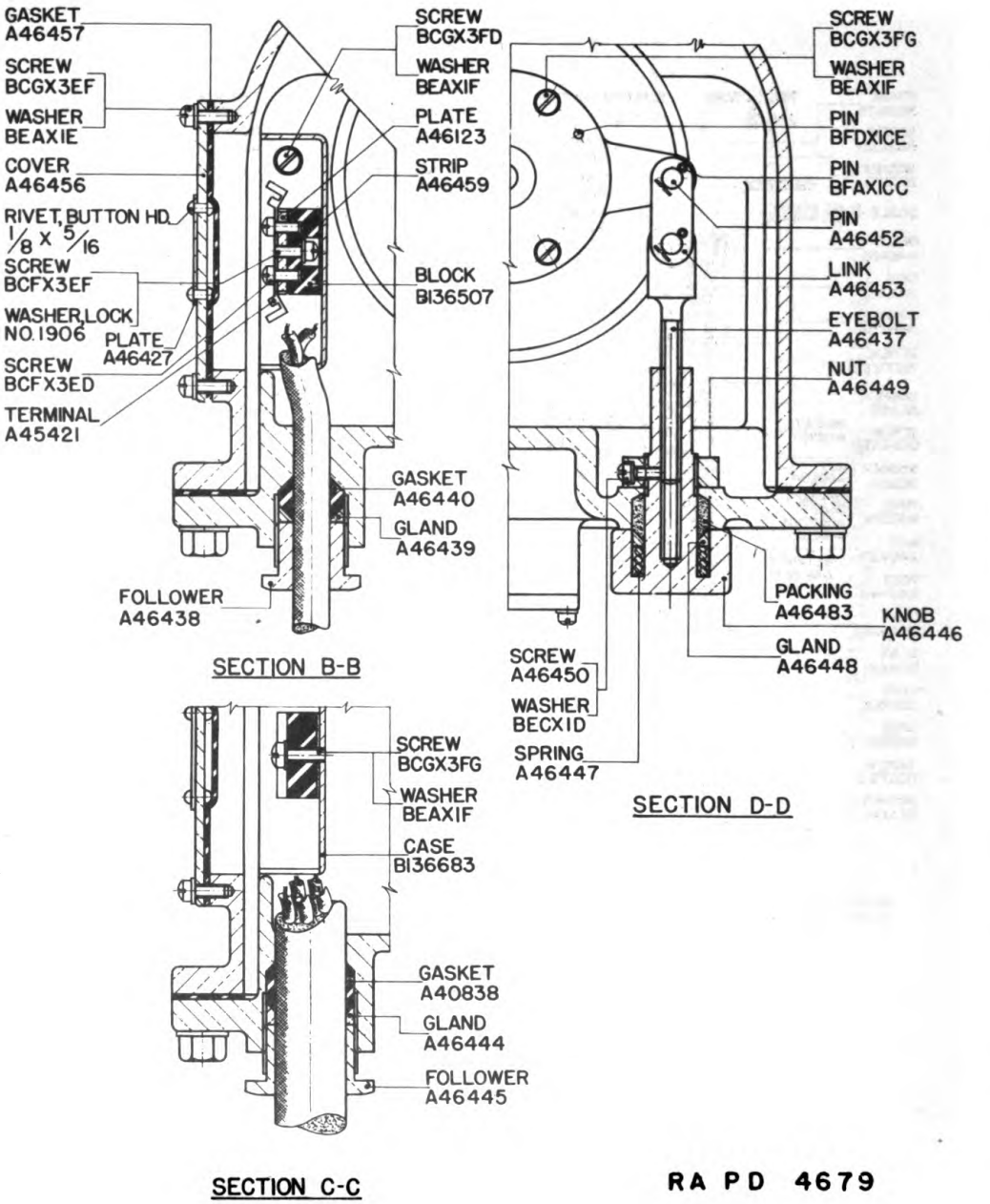

FIGURE 21 — FUZE INDICATOR, M3 - SECTIONED VIEWS

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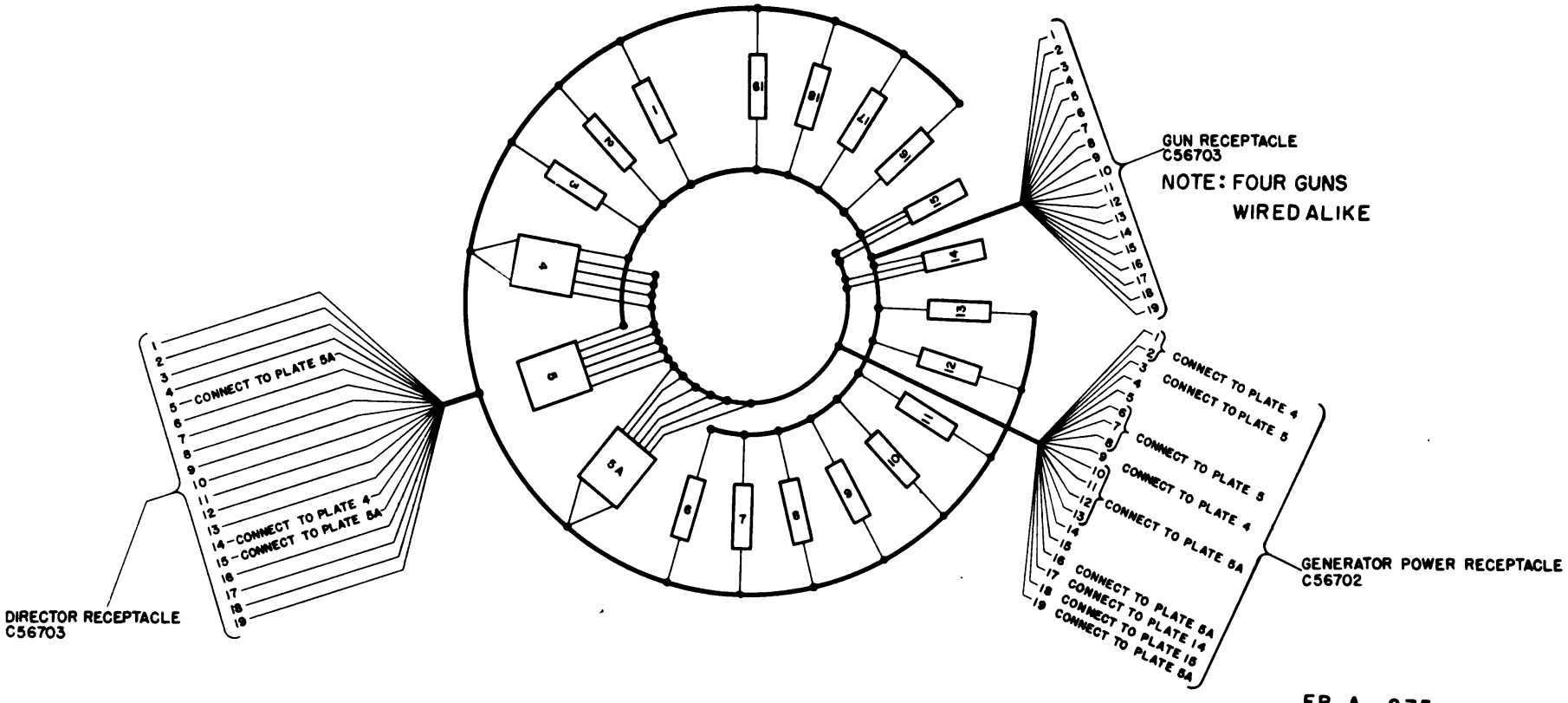

FIGURE 22 — MAIN JUNCTION BOX - WIRING DIAGRAM

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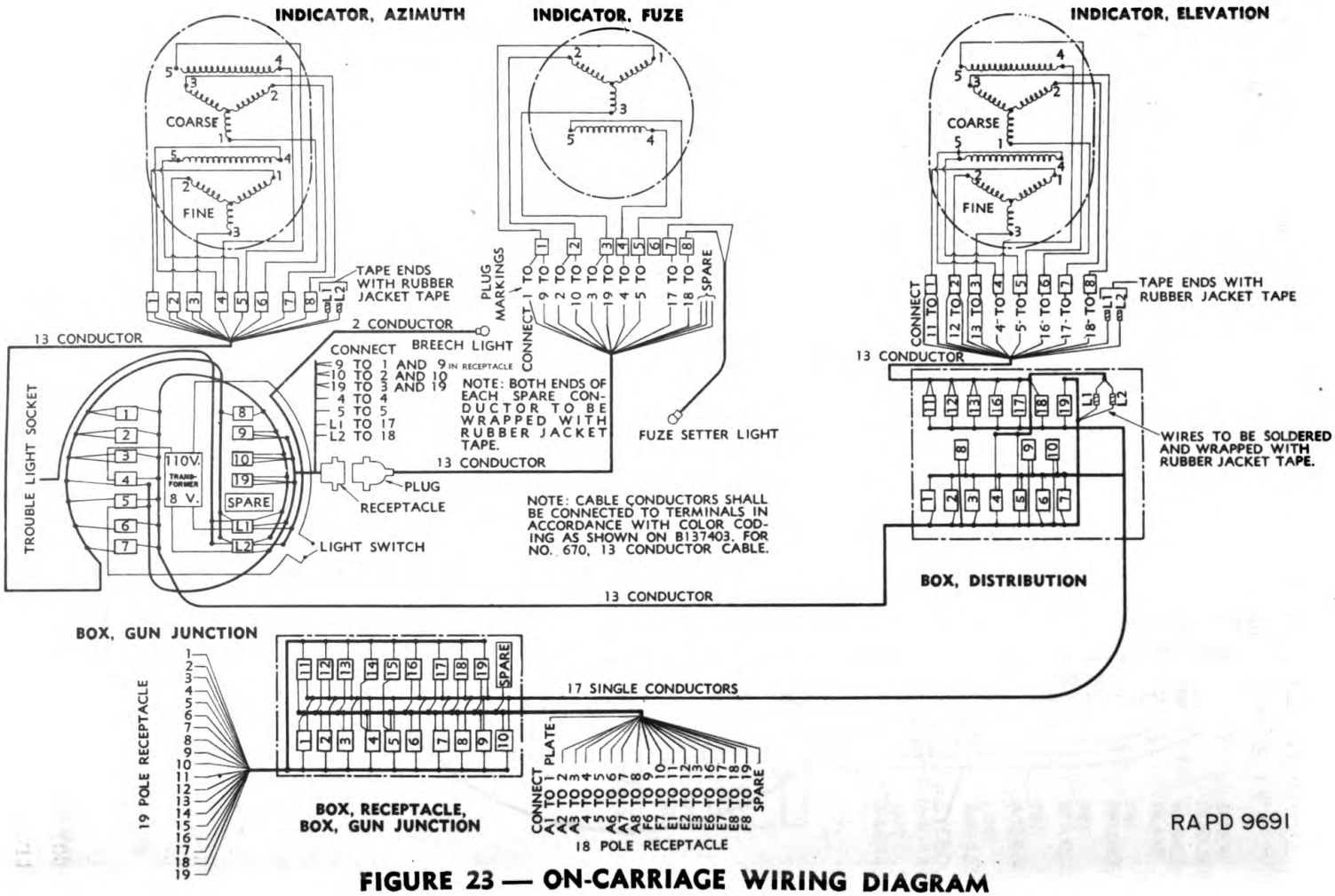

FIGURE 23 — ON-CARRIAGE WIRING DIAGRAM

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is inclosed in a watertight case, provided with a nonshatterable glass window through which the dial and index pointer may be seen. The index pointer and dial pointer are filled with luminous radium paint. Graduations and numbers of the fixed scale are filled with white enamel.

b. Two fuze scales are provided for alternate use. One scale (B136679) is calibrated to 21 seconds (Figure 19), and is used with fuze, Mk. III. The other scale (B136406) is calibrated to 30 seconds, and is used with the mechanical fuze. The scales are fastened to posts by four fillister head screws. The "S" on the scale represents the "safe" or unset position of the fuze.

c. The knob (A46446, Section D-D, Figure 21) rotates the repeater through about 15° on either side of the zero position to synchronize the repeater with the director transmitter at zero setting.

d. The packing gland (Figure 20, Section A-A) seals the shaft (A46428) and the bearing opening into the body of the fuze indicator against oil, grit and moisture.

e. Electrical connections are brought out to the terminal block (B136507) and thence to the packing gland and the exterior. The terminal block may be reached by removing the cover (A46456, Section B-B, Figure 21).

13. CABLE ASSEMBLIES. - a. (1) Twelve cable, plug, and receptacle assemblies, 225 feet long, No. 950, 20-conductor (B137024, Figures 1 and 24 to 29) are used in the system. These are usually distributed as follows:

(a) One between height finder and director.

(b) Four between director and main junction box.

(c) Three between power plant and main junction box.

(d) One each, between main junction box and the four guns comprising a battery.

(2) Since the cables are interchangeable, the cable arrangement may be altered from that indicated above to best suit the arrangement of the guns and connected equipment. See paragraph 16.

(3) The cable, plug and receptacle assembly (B137024) includes the 19-pole plug assembly (Figure 26) which has a cap screwed on for watertightness, etc., 225 feet of 20-conductor transmission cable, type XIII, and another 19-pole receptacle assembly (C69778, Figure 25) which also has a cap.

(4) Connections are soldered to fingers and terminals in accordance with color coding (Figure 29) and plug-and-receptacle engravings (Figure 27).

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NOTE: CONDUCTORS TO BE SOLDERED TO FINGERS AND TERMINALS IN RECEPTACLE AND PLUG IN ACCORDANCE WITH COLOR CODING AND CONNECTIONS INDICATED ON DRAWING NO. A48711. ALL SOLDERED JOINTS AND BRAID IN VICINITY OF THE JOINTS SHALL BE PAINTED WITH INSULATING MATERIAL (GLYPTAL RED OR EQUAL) ENDS OF SPARE CONDUCTOR TO BE TAPED WITH RUBBER JACKET TAPE.

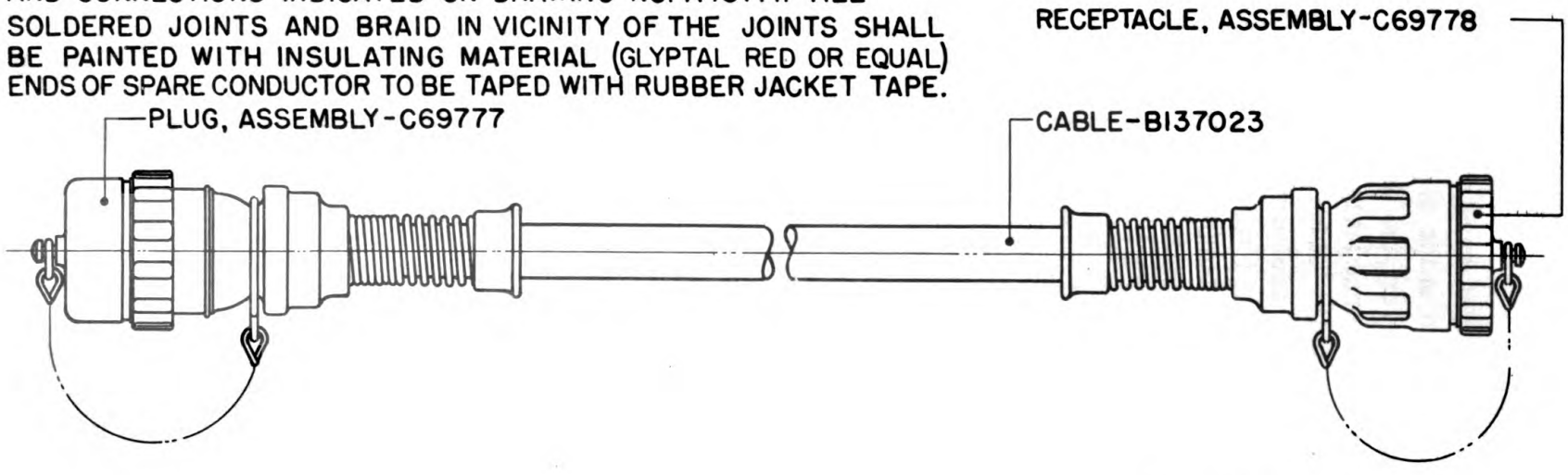

FIGURE 24 — PLUG AND RECEPTACLE CABLE - ASSEMBLY

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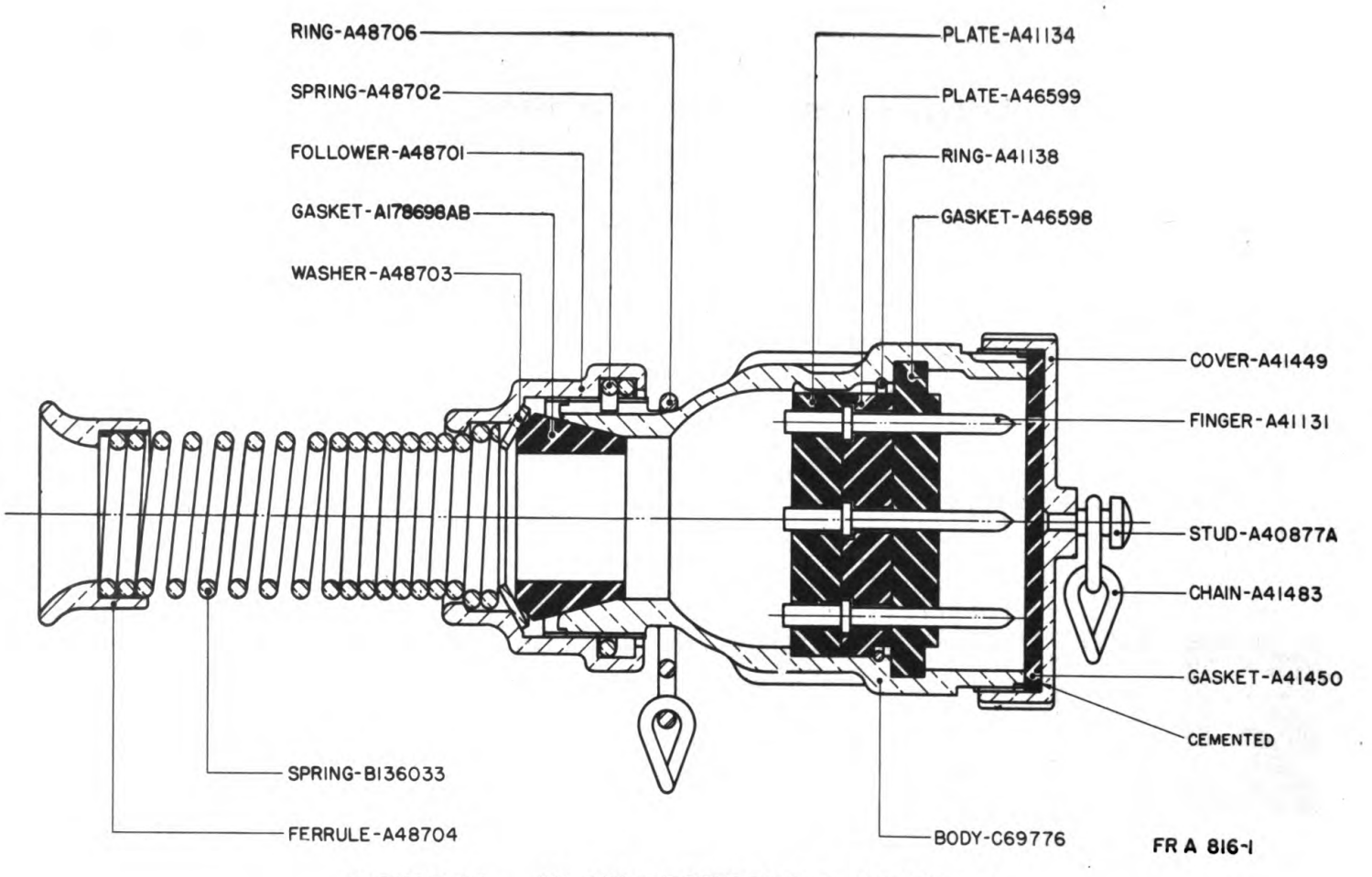

FIGURE 25 — 19 POLE RECEPTACLE - ASSEMBLY

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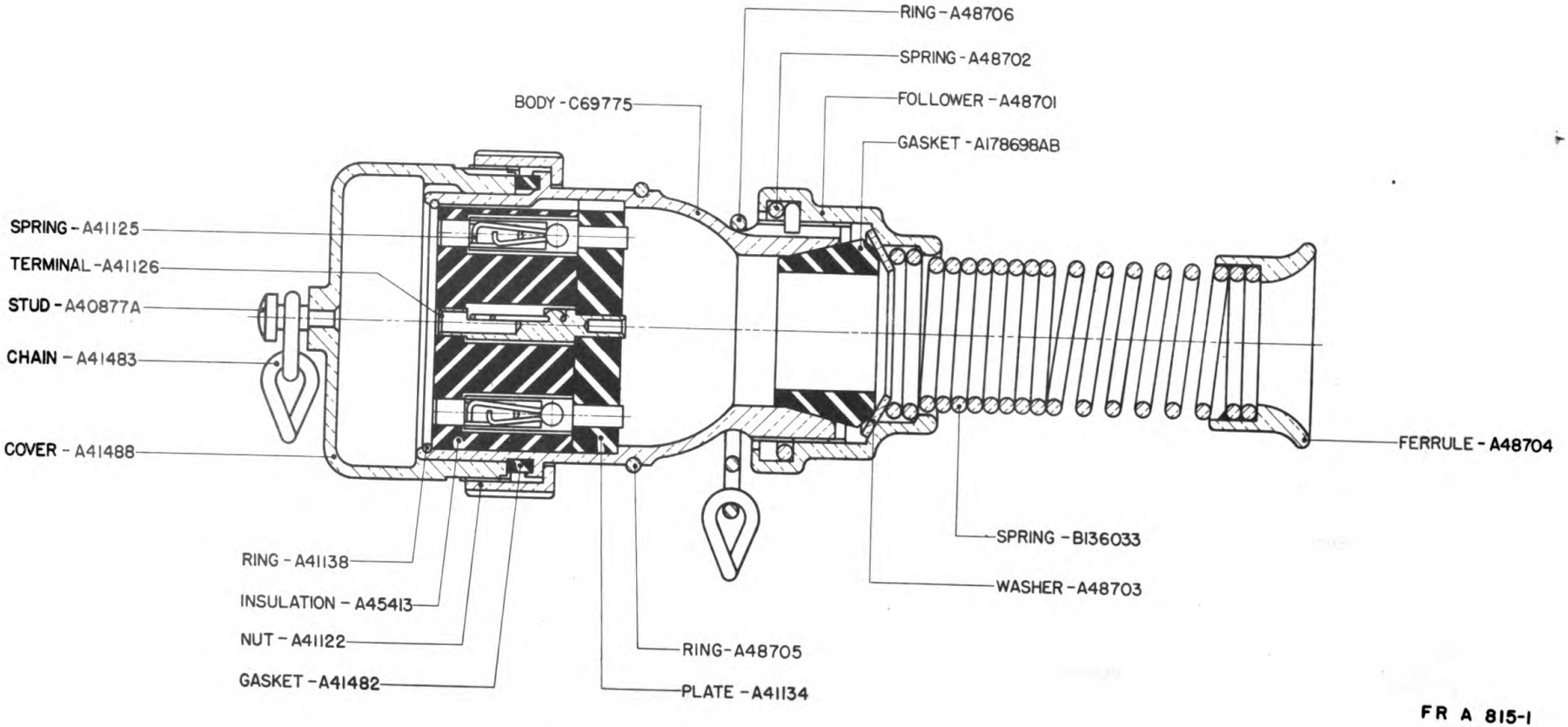

FIGURE 26 — 19 POLE PLUG - ASSEMBLY

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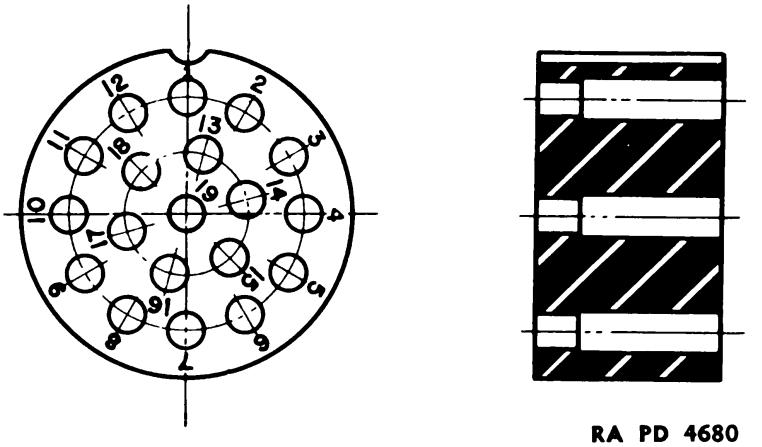

FIGURE 27 — ENGRAVING FOR RECEPTACLE TERMINAL INSULATION

20 CONDUCTOR TRANSMISSION CABLE COLOR CODING OF CONDUCTORS CONNECTED TO TERMINALS		
TERMINAL MARKINGS	COLOR CODING OF CONDUCTORS	DATA LINES
1 2 3	ORANGE FIELD - WHITE TRACE ORANGE FIELD - BLACK TRACE ORANGE	AZIMUTH, FINE
4 5	WHITE BLACK	POWER, 115 V.
6 7 8	RED FIELD - WHITE TRACE RED FIELD - BLACK TRACE RED	AZIMUTH, COARSE
9 10	GREEN FIELD - WHITE TRACE GREEN FIELD - BLACK TRACE	FUZE
11 12 13	BLUE FIELD - WHITE TRACE BLUE FIELD - BLACK TRACE BLUE	ELEVATION, FINE
14 15	WHITE FIELD - BLACK TRACE BLACK FIELD - WHITE TRACE	POWER, 115 V.
16 17 18	YELLOW FIELD - WHITE TRACE YELLOW FIELD - BLACK TRACE YELLOW	ELEVATION, COARSE
19	GREEN	FUZE
	SLATE	SPARE

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FIGURE 28 — 20 CONDUCTOR TRANSMISSION CABLE - COLOR CODING

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13 CONDUCTOR TRANSMISSION CABLE, TYPE VIII

COLOR CODING OF CONDUCTORS CONNECTED TO TERMINALS

CONNECT COLOR CODED CONDUCTORS TO TERMINALS MARKED IN						COLOR CODING OF CONDUCTORS	BASIC DATA LINES	MULTIPLE CONNECTIONS OF CONDUCTORS FOR DATA LINES
DISTRIBUTION BOX (ELEVATION INDICATOR CABLE)	DISTRIBUTION BOX AND GUN JUNCTION BOX (ACROSS CARRIAGE CABLE)	GUN JUNCTION BOX (AZIMUTH INDICATOR CABLE)	AZIMUTH OR ELEVATION INDICATOR (AZIMUTH OR ELEVATION INDICATOR CABLE)	FUZE SETTER (FUZE INDICATOR CABLE)	CABLE RECEPTACLE (FUZE INDICATOR CABLE) ◑			
11	1	1	1	1	1	ORANGE FIELD-WHITE TRACE	AZIMUTH OR ELEVATION (FINE)	FUZE OR AZIMUTH OR ELEVATION (FINE)
12	2	2	2	2	2	ORANGE FIELD-BLACK TRACE		
13	3	3	3	3	3	ORANGE		
4	4	4	4	4	4	WHITE	POWER 115 VOLT	
5	5	5	5	5	5	BLACK		
16	6	6	6	⊕	⊕	RED FIELD-WHITE TRACE	AZIMUTH OR ELEVATION (COARSE)	
17	7	7	7	⊕	⊕	RED FIELD-BLACK TRACE		
18	8	8	8	⊕	⊕	RED		
11	9	1	1	1	9	GREEN FIELD-WHITE TRACE	FUZE	FUZE OR AZIMUTH OR ELEVATION (FINE ONLY)
12	10	2	2	2	10	GREEN FIELD-BLACK TRACE		
13	19	3	3	3	19	GREEN		
L1	L1	L1	*	L1	17	WHITE FIELD-BLACK TRACE	POWER 6 VOLT	
L2	L2	L2	*	L2	18	BLACK FIELD-WHITE TRACE		

⊕ = ENDS TO BE WRAPPED WITH RUBBER JACKET TAPE.

* = SOLDER TO LAMP LEADS IN AZIMUTH OR ELEVATION INDICATOR

◑ = TERMINALS 6,7,8 AND 11 TO 16 INCL. NOT CONNECTED

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FIGURE 29 — 13 CONDUCTOR TRANSMISSION CABLE - COLOR CODING

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b. One cable of 17 single conductors (Figure 1) in brass tubing, is used between the receptacle box and the distribution box. See wiring diagram (Figure 23).

c. Two 13-conductor cables, 34 inches long, (B137025) are used; one between distribution box and elevation indicator, one between gun junction box and azimuth indicator. See Figure 1.

d. One 13-conductor cable, No. 670, in brass tubing is used between the distribution box and gun junction box.

e. One 13-conductor cable-and-receptacle assembly, 43 inches long, (B136723, Figure 1) is used between gun junction box and fuze indicator. One end is attached to the terminal block of the fuze indicator in accordance with the color code and terminal plate markings. On the other end is the 19-pole receptacle assembly (C69421) which plugs into the gun junction box.

f. One 2-conductor cable-and-plug assembly, 46 inches long (B136042, Figure 30) for the breech light, is wired to gun junction box terminals L1 and L2 and has a plug (A48618) for insertion into the breech light receptacle.

g. One 2-conductor cable-and-plug assembly, 37 inches long (B136043) for the fuze setter light is wired to terminal block (B136507) of the fuze indicator (Figure 21, Section B-B). The cable-and-plug assembly has a plug (A48618) for insertion into the receptacle of the fuze setter light.

14. GENERATING UNIT, M3. - a. General. - The generating unit, M3, supplies power for the data transmission system, M3. The unit consists primarily of a 2-1/2 kva, 115-125 volt, 60-cycle, a-c generator driven by a 10 horsepower gasoline engine. Two generating units are supplied with each data transmission system. One unit is to be held in reserve in case of a breakdown of the unit being used. Each unit is enclosed in a metal hood and is arranged to be lifted and carried short distances by porter bars. Weight of each unit is about 800 pounds. See Figures 31 to 37.

b. Generator. - The generator has the following characteristics: Single phase, a.c., 115-volt, 60-cycle, 1200 rpm, and self-excited revolving field. The generator is rated at 2-1/2 kva at 90% load power factor and operates satisfactorily at as low as 50% power factor. The 15-volt exciter which supplies d-c current to the revolving field, is mounted integrally on the generator armature shaft. The exciter also carries a 5 amp. charging current for the storage battery. Radial

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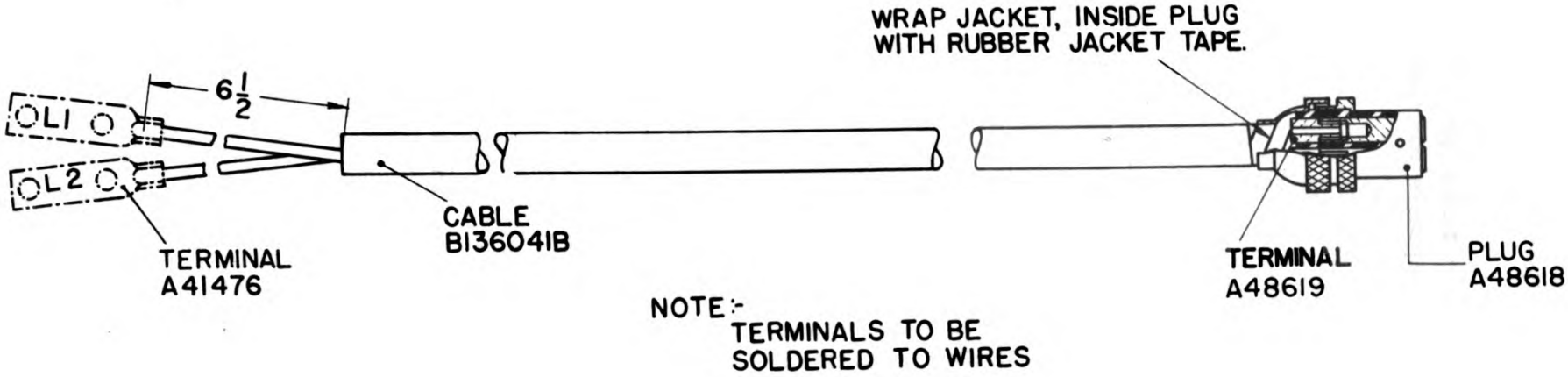

FIGURE 30 — CABLE AND PLUG ASSEMBLY FOR BREECH LIGHT

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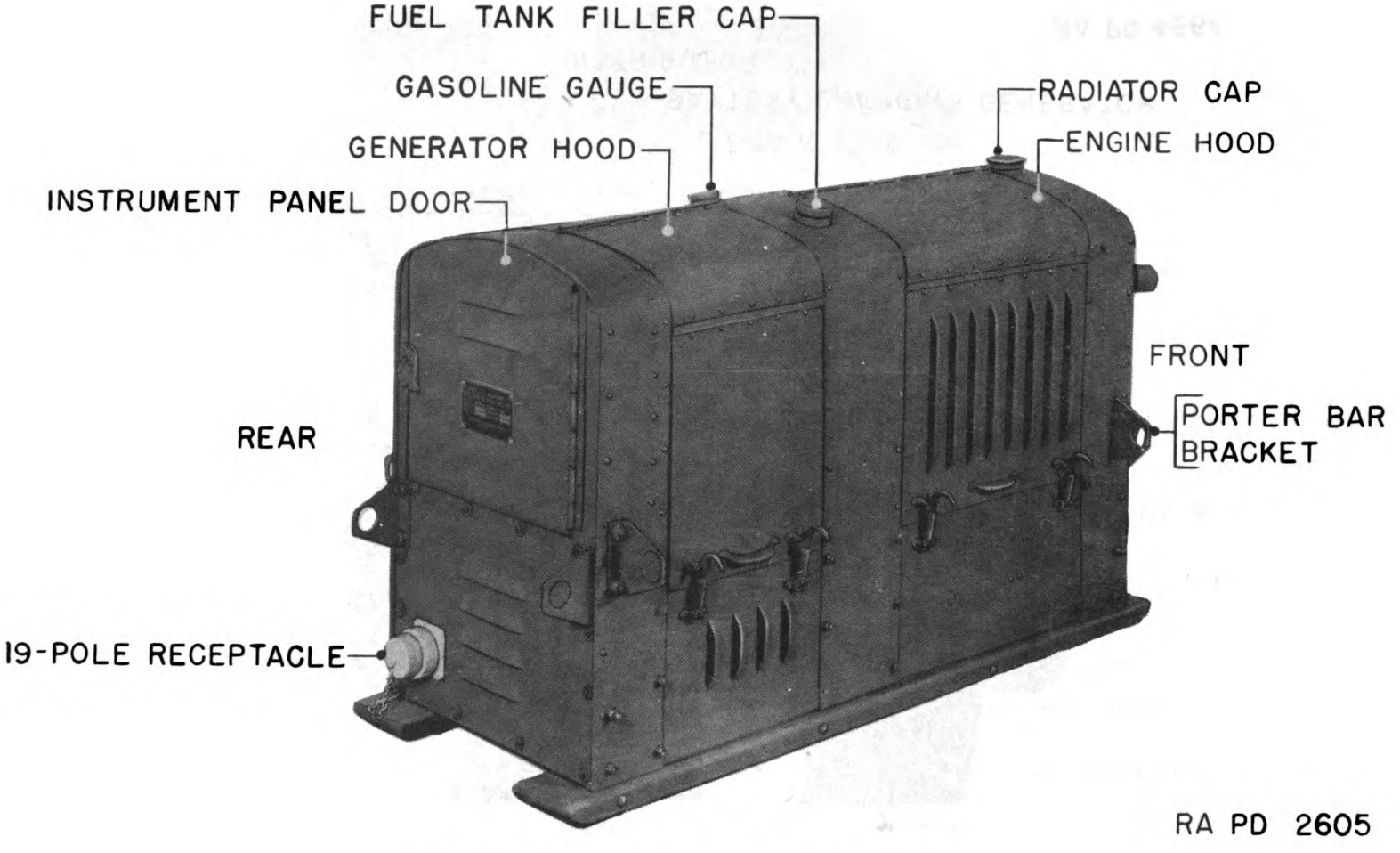

FIGURE 31 — GENERATING UNIT, M3

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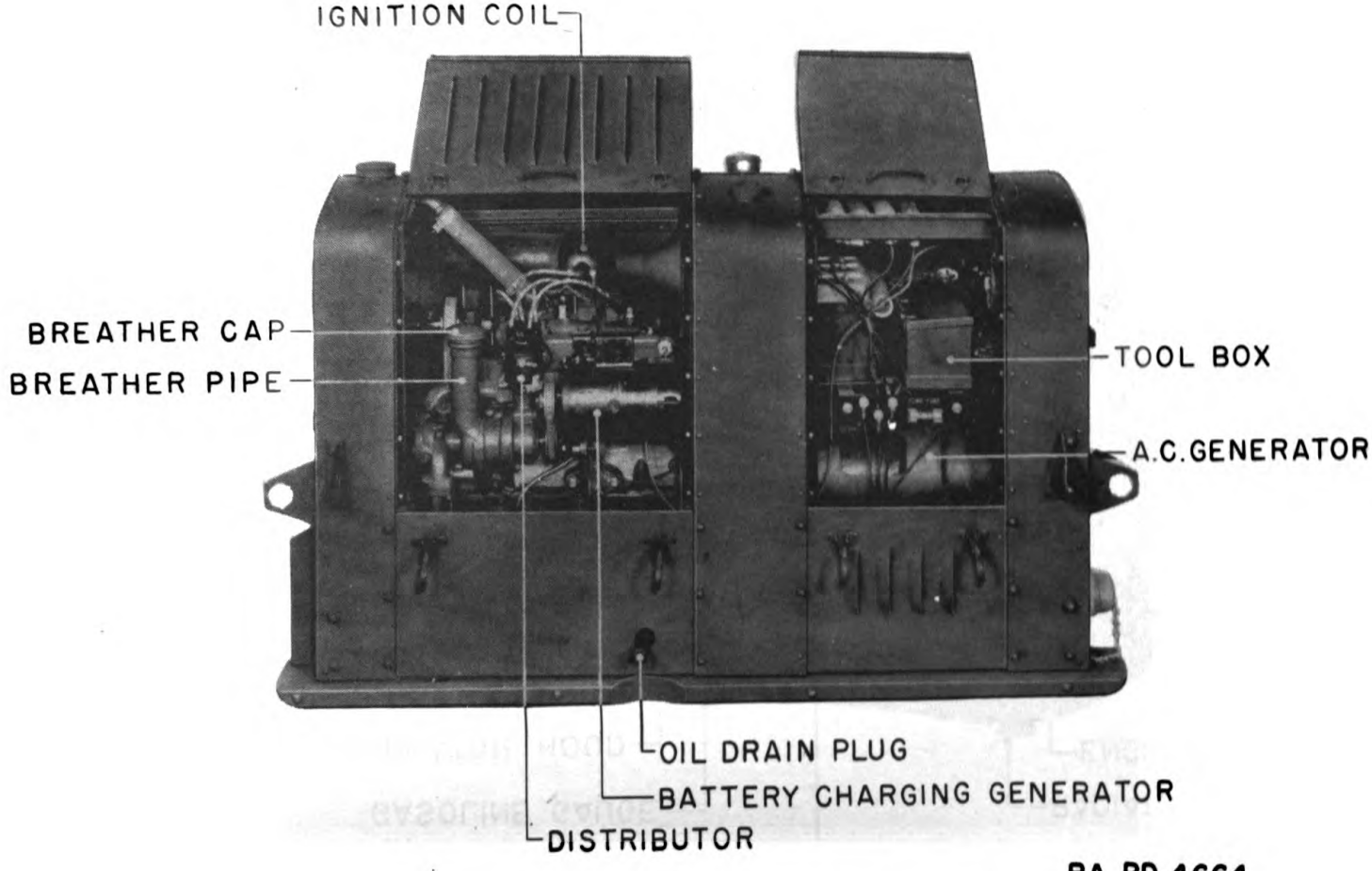

FIGURE 32 — GENERATING UNIT, M3 - LEFT SIDE

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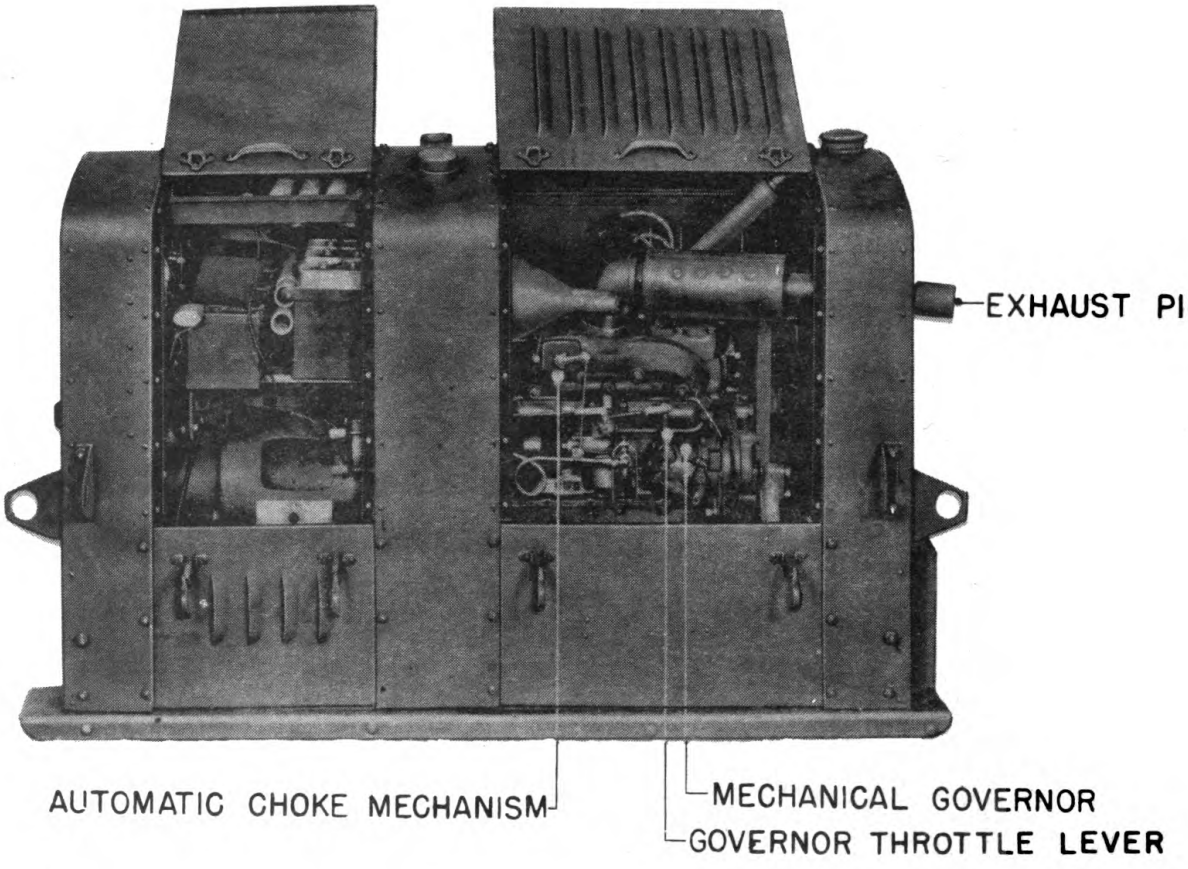

FIGURE 33 — GENERATING UNIT, M3 - RIGHT SIDE

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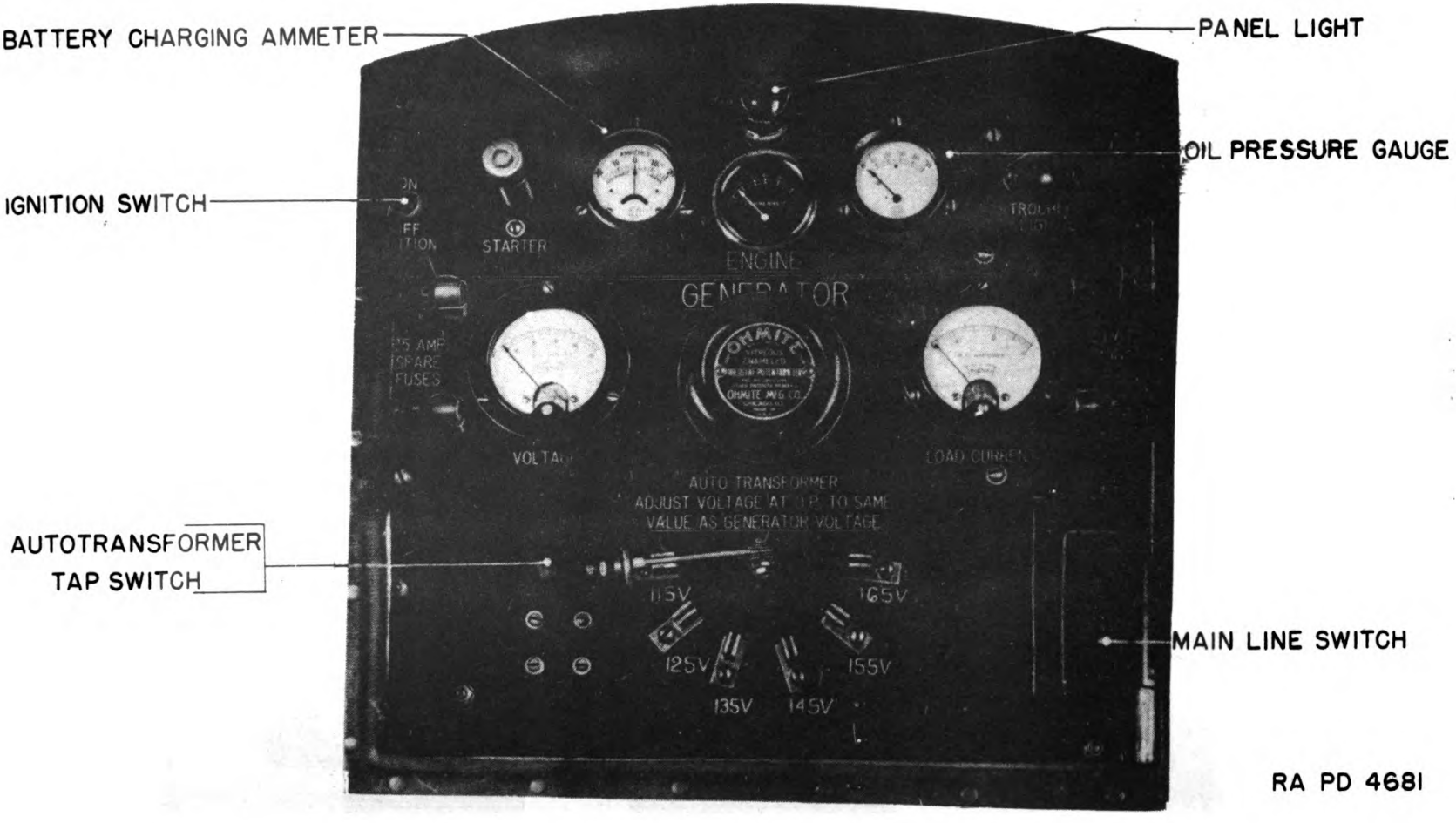

FIGURE 34 — GENERATING UNIT, M3 - PANEL BOARD

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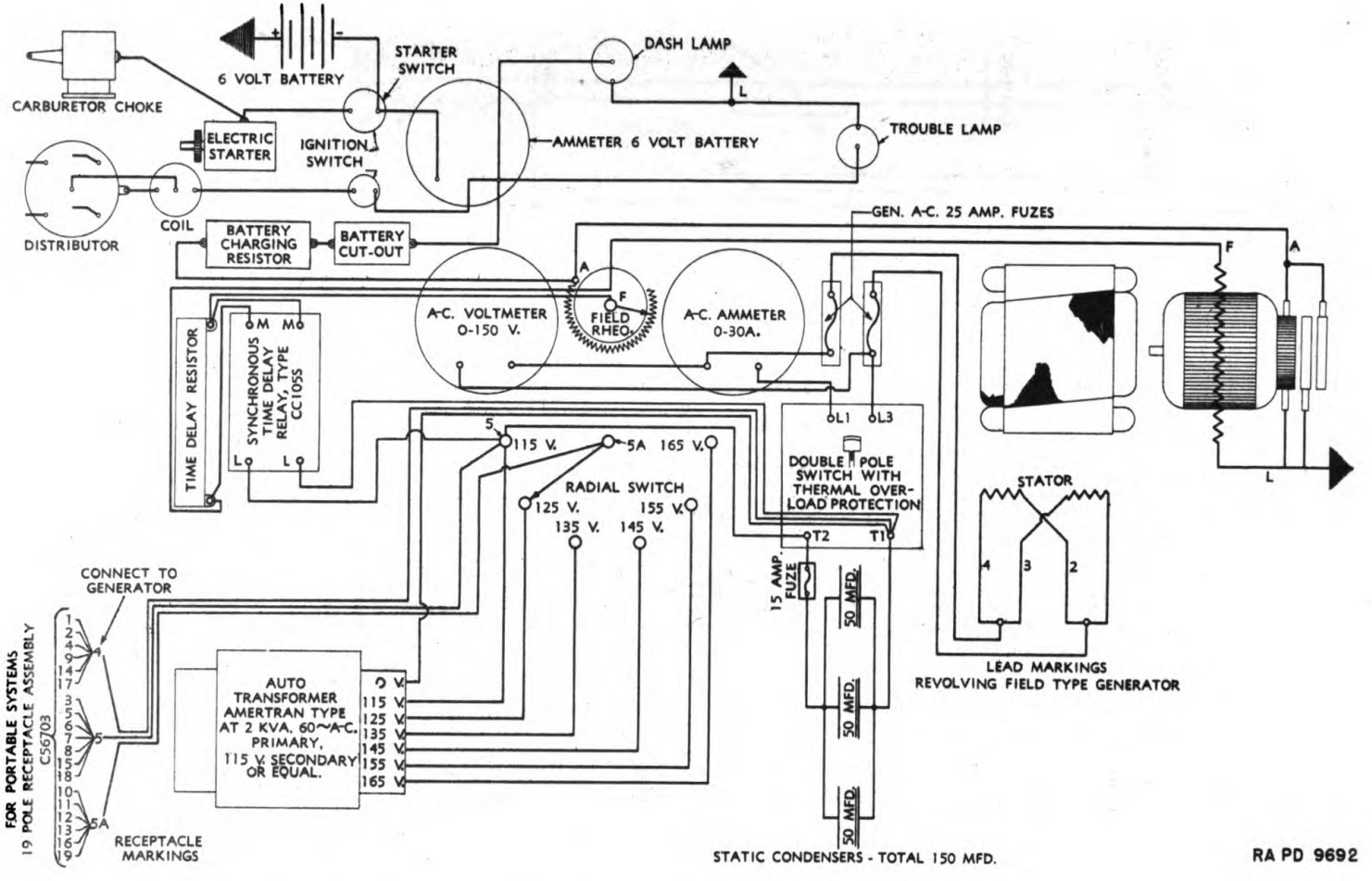

FIGURE 35 — GENERATING UNIT, M3 - WIRING DIAGRAM

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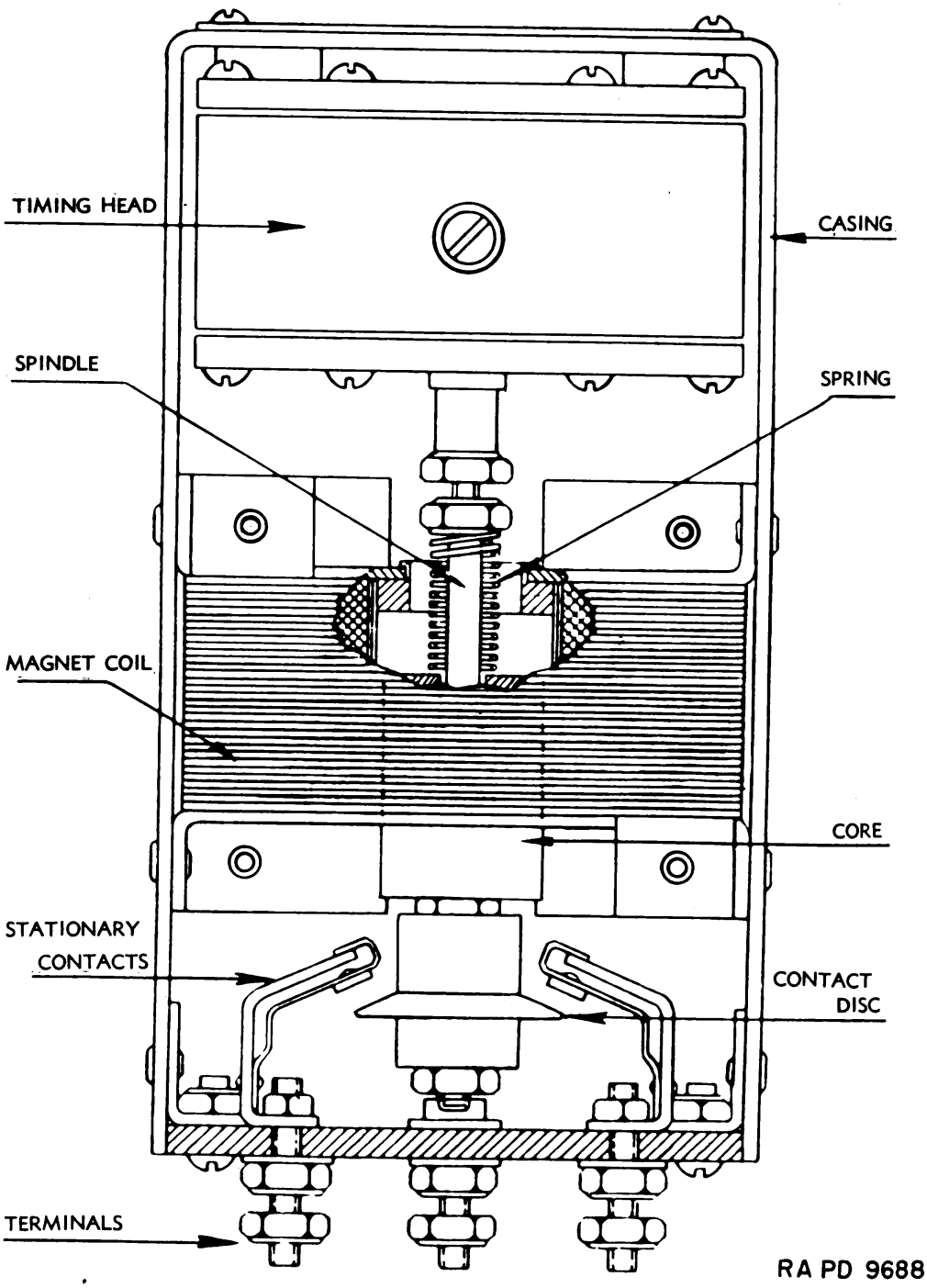

FIGURE 36 — GENERATING UNIT, M3 - TIME DELAY RELAY

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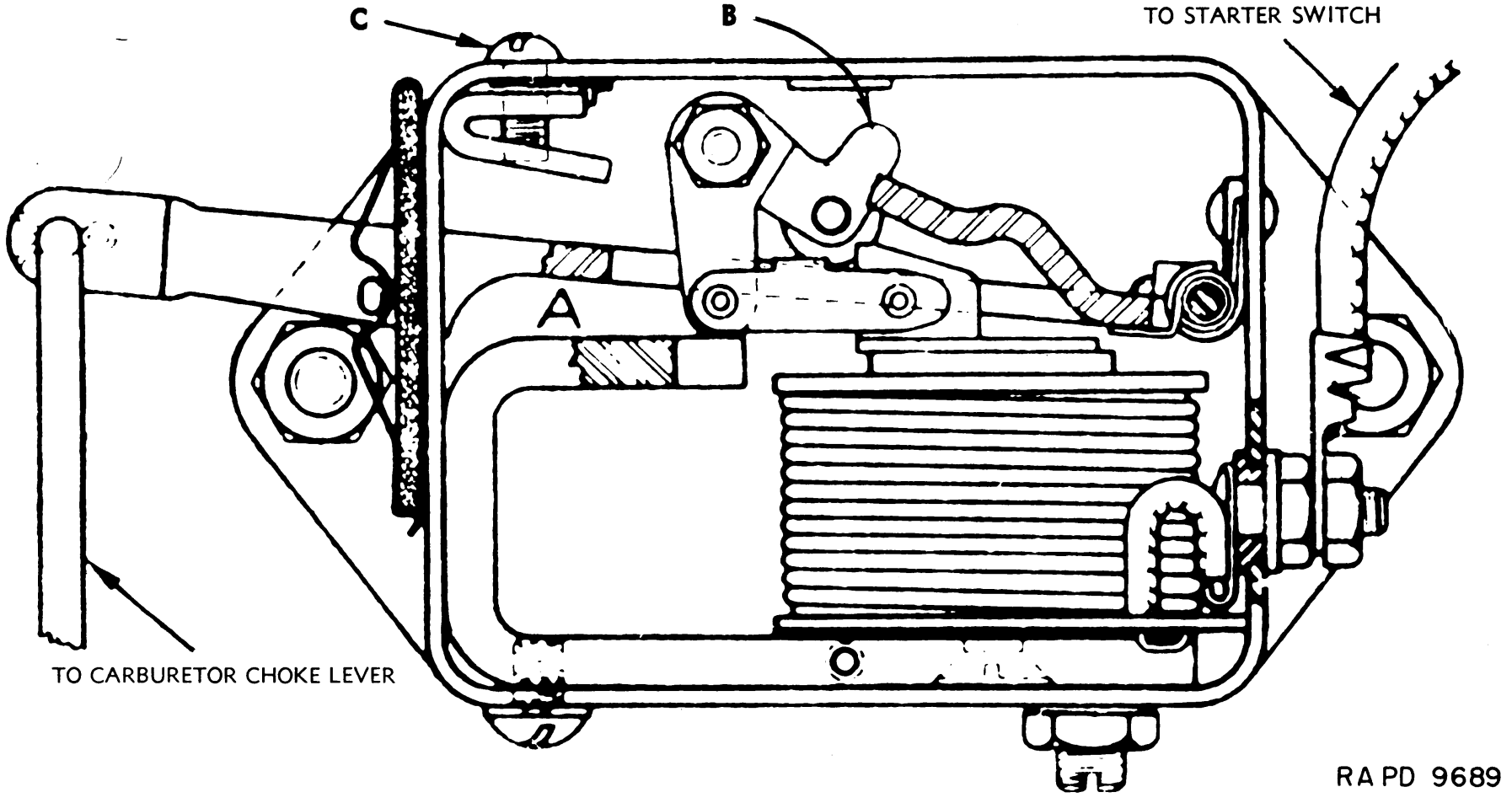

FIGURE 37 — GENERATING UNIT, M3 - AUTOMATIC CHOKE

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type brushholders are used. A fan mounted on the armature shaft provides ventilation to protect the coils against overheating.

c. Gasoline engine. - (1) Engine specifications:

Model ZXA ------	4 cylinder, cast in block, with water jacket, with detachable cylinder head, manifolds and crankcase, aluminum bellhousing, aluminum charging generator support and aluminum front engine support.	
Rating --------	Bore and stroke, in. -----	2-1/2 x 3
	Number of cylinders ------	4
	N.A.C.C. horsepower ------ (National Automobile Chamber of Commerce)	10
	Piston displacement, cu. in. -	58.8
	Firing order	1-2-4-3
Valves --------	Arrangement	L-Head
	Exhaust valve diameter, clear, in. ----------	7/8
	Intake valve diameter, clear, in. ----------	1-1/8
Pistons -------	Material ----------	Cast iron
	Rings above pin ----------	3
	Rings below pin ----------	0
	Ring width, compression, in.	1/8
	Ring width, oil, in. -----	3/16
Piston pin ----	Diameter, in. ----------	11/16
	Bearing length, in. ------	1-3/8
	Bearing location ---------	In piston
	Number of bearings -------	2
Crankshaft ----	Number of bearings -------	3
	Bearing diameter, in. ----	2
	Bearing length (front), in.	1-5/16
	Bearing length (center), in.	1-3/8
	Bearing length (rear), in.	1-3/8
Camshaft ------	Drive ----------	Helical gear
	Number of bearings ----	4
	Diameter (front, center and rear), in. ------	1-1/4
	Length (front), in. ---	1-1/8
	Length (center) No. 2 and 3, in. ----------	19/32

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DESCRIPTION

Camshaft (Continued)
Length (rear), in. ---------- 19/32
Location - right hand side, looking at flywheel.
Connecting rods-Connecting rod bearings diameter, in. ---------- 1-1/2
Connecting rod bearings length ---------- 1
Connecting rod length, c to c, in. ---------- 5-1/8
Carburetor size ---------- 5/8 in. SAE
Cooling ---------- Water pump
Generator mounting - Aluminum special casting machined to fit - flange type.
Starter mounting --- Aluminum special casting machined to fit - flange type.
Spark plug, size ---------- 14 mm metric
Exhaust manifold bore, in. ---------- 1-17/32 bore
Method of suspension ---------- 4 point

(2) Cylinder block, cylinder head, and crankcase. - The cylinder block and crankcase are cast in one piece. Water jacketing extends full length of the bore. Three large main bearings with babbitt lined shells for top half of bearings and babbitt lined caps for lower half of bearings support the shaft. The caps are secured by cap screws. End thrust is controlled by flanges on the rear main bearing. The cylinder head is water jacketed and is removable for cleaning carbon and grinding valves.

(3) Connecting rods and pistons. - The connecting rods and caps have poured babbitt bearings and are bolted together. The connecting rod clamps the piston pin to avoid scoring the cylinder walls. The cast iron pistons are each grooved for two compression rings and one oil ring and have bronze bushings for the piston pins. Where special alloy pistons are used the bronze bushings are not used, as the alloy is a suitable bearing for the pin.

(4) Automatic choke. - The automatic choke of electrothermal type shown in Figure 37, is operated by an electromagnet and a thermostat. This device is mounted on the exhaust manifold and is connected to the carburetor choke lever by a small rod. The electromagnet is connected in the starter circuit. When the starter button is pressed, current flows through the

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electromagnet and the armature lever is pulled down, thus giving a full carburetor choke. When the starter button is released, current ceases to flow through the electromagnet and the amount of carburetor choke is then regulated by the temperature of the engine through the medium of the thermostat.

(5) Governor. - A centrifugal mechanical type governor of commercial design regulates the speed of the engine. The governor will maintain engine speed at 1,200 rpm ± 60 rpm (60 ± 3 cycles) but ± 100 rpm (± 5 cycles) is satisfactory for the system. The device is located below and ahead of the carburetor. It is linked to the throttle valve by an adjustable rod.

(6) Cooling. - A radiator, fan, and packless-type circulating pump supplies cooling water to the engine jackets. Capacity of the system is 1 gallon. A petcock in the lower part of the cylinder block and an outlet in the bottom of the radiator are used for drainage. The fan blows air outward through the radiator.

(7) Fuel. - Standard gasoline is stored in the 5 gallon tank above the flywheel end. A float type fuel level gage is provided in the tank. A shutoff cock, a standard automotive filter with bowl, a filter screen and a sediment trap are provided in the fuel line below the tank. Intake air is filtered by an air cleaner.

(8) Storage battery and starter motor. - A 6-volt, 100 ampere-hour capacity, storage battery and a 6-volt starting motor are provided.

d. Panel board. - The panel board (Figure 34) is provided with the following equipment:

(1) Dash lamp with self-contained switch for illuminating switchboard.

(2) Socket for trouble light.

(3) Ammeter to indicate battery current (-20, 0, +20 amperes).

(4) Oil pressure gage (0 to 50 pounds per sq. in.).

(5) Engine temperature indicator.

(6) Engine starting switch.

(7) Engine ignition switch.

(8) A-c voltmeter (0 to 150 volts).

(9) A-c ammeter (0 to 30 amperes).

(10) Field rheostat, rotary type, with control knob. (Total resistance 3 ohms, maximum current 10 amperes.)

(11) Main switch, double pole, single throw, with overload circuit-breaker protection.

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(12) Output line fuses (25 amperes) and 2 spare fuzes mounted in clips.

(13) An autotransformer tap switch, radial knife type, for adjusting primary voltage at director terminals.

(14) 19-pole receptacle, mounted on end cover below panel board.

e. Additional equipment. - (1) Autotransformer. - The autotransformer (Figure 35) is rated at 2 KVA; 60-cycle a.c.; primary tap for 115 volts; secondary taps for 115, 125, 135, 145, 155, and 165 volts. This transformer, controlled by the radial knife switch equalizes the voltage at the director terminals and gun data indicators. The terminal voltage of the generator is controlled by the field rheostat and is indicated by the a-c voltmeter on the panel board.

(2) Time delay relay. - The time delay relay mounted on the back of the panel board permits excitation of the transmitters and repeaters at reduced voltage when they are stabilizing at the synchronous position. The relay is set for 5 seconds delay and actuates the auxiliary relay.

(3) Auxiliary relay. - The auxiliary relay has contacts capable of carrying the full load current. It is mounted on the back of the panel board. The auxiliary relay is operated by the time delay relay.

(4) Line resistor. - A 10-ohm resistor is connected in series with the load circuit to reduce the line voltage during the delay period, and then is shunted by the auxiliary relay.

(5) Static condensers. - Three 50-mfd., 110-volt, 60-cycle, oil-impregnated fixed condensers connected to the output terminals of the main switch, improve the power factor. A 15-ampere fuse, in series with the condensers, cuts out the condensers in case they become short-circuited.

(6) Tool box. - The tool box in the generating unit, M3 contains a socket type spark plug wrench, a screwdriver; a pair of 6-inch slip joint pliers, a set of open end wrenches in cloth tool roll, a funnel, a hand crank, a valve lifter, and a revolution counter.

(7) Electrical testing equipment. - A voltmeter, ammeter and ohmmeter with carrying cases are supplied.

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SECTION III

OPERATION

	Paragraph
General	15
Arrangement of units	16
Connecting cables	17
Generating unit	18
Starting and stopping	19
Operation from commercial power supply	20

15. GENERAL. - When the data transmission system has been set up and oriented with the director, height finder, etc., its operation is largely automatic and is controlled by the functioning of the director and height finder.

16. ARRANGEMENT OF UNITS. - Although not essential for satisfactory operation, the following considerations should be borne in mind:

a. The total length of cable between the main junction box and each gun should be approximately the same, even though the linear distance to each gun is different.

b. To facilitate target designation the height finder should be set up near the director position.

c. The power plant should not be more than 600 feet from the main junction box.

d. The director offset should not exceed 1,200 feet.

17. CONNECTING CABLES. - a. The leads are color-coded and connected to terminals as indicated in the tables for 13-conductor transmission cable (Figure 29) and 20-conductor transmission cable (Figure 28).

b. When plugging into the receptacle aline the keys and keyways.

c. Tighten the round nuts on the plugs and receptacles after insertion of plugs to insure tight connection.

d. Several of the cables are interchangeable and hence the cable plugs and receptacles are not painted to correspond with matching parts.

e. Where one cable connects two units the plugs and receptacles on the units to be connected are painted one color.

f. The cable connected to the generating unit must never be plugged into any receptacle other than the yellow one in the main junction box marked "Power Plant".

18. GENERATING UNIT. - a. Lubrication. - Check the oil level in the crankcase and fill if necessary. If oil is dirty,

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drain and refill with new oil. A plug is provided for draining. Refill through the breather pipe and replace the breather cap immediately. The oil level is indicated on a bayonet type (dip stick) gage located on the same side of the crankcase; the graduation marked 4/4 indicates a full crankcase, 2/4 half full, etc. See lubrication chart, SECTION VI.

b. Radiator. - Fill radiator with clean, fresh, alkali-free water or, if necessary, with antifreeze solution:

(1) A number of reliable antifreeze solutions are available, but the use of such solutions must be preceded by careful investigation to determine whether or not they may prove detrimental to the radiator, engine, or hose. A solution of denatured alcohol may be used without appreciable damage to the cooling system. The following table shows proper proportions for the various temperatures:

Temperature (^{O}F.)	Percent alcohol	Percent water	Specific gravity	Boiling point (^{O}F.)
30 to 22	10	90	0.980	190
22 to 10	20	80	.973	180
10 to - 2	30	70	.964	165
- 2 to - 14	40	60	.953	160
- 14 to - 20	45	55	.945	150
- 20 to - 40	50	50	.933	135

(2) Use of a greater percentage of alcohol than temperature conditions require may result in overheating of the engine.

(3) The capacity of the cooling system is approximately 1 gallon.

c. Fuel. - Fill the fuel tank with standard gasoline. Extreme care must be taken to avoid spilling gasoline. The capacity of the tank is 5 gallons. Fuel level is indicated on the gage and may also be checked by inserting a clean dry stick or rod and noting the liquid level indicated thereon. Open valve under fuel tank.

d. Battery. - Place the 100-ampere-hour storage battery, filled with electrolyte and fully charged, in the compartment below the radiator of the unit and fasten in place with the fittings provided. Connect the red lead to the red or positive post, and the other lead to the negative post. The ignition switch must be left "OFF" until ready to start.

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e. Indoor operation. - If operating indoors, piping should be arranged to exhaust fumes out of doors. Connection is made to the exhaust pipe projecting through the radiator. Standard 1-1/4 inch pipe will be satisfactory.

19. STARTING AND STOPPING. - a. Make sure the main switch is "OFF".

b. Throw ignition switch "ON".

c. Press starting button. As soon as the engine starts, release the starter button and allow engine to run and warm up for a few minutes.

d. Connect the generator to the load by turning the main switch "ON". This step allows current to pass through the 10-ohm resistor until the time delay relay and auxiliary relay shunt the current around the resistor. The terminals will then be excited at full voltage.

e. After the engine has been running for fifteen or twenty minutes check the speed with the revolution counter provided. With no external load connected to the unit, the engine should run at a speed of 1,200-1,250 rpm.

f. To stop the unit, first open the main switch. This action takes the load off the generator. Then turn the ignition switch "OFF".

20. OPERATION FROM COMMERCIAL POWER SUPPLY. - This system will also operate satisfactorily from any ordinary commercial source of single phase a-c power of 110 to 120 volts, 60-cycles. Connection to the supply is made by terminals 4 to 5 in the main junction box, with terminals 5 and 5A connected together. A suitable 2-pole switch to open both sides of the circuit must be provided and each side must be protected by a 25-ampere fuse. As the power cannot then be applied gradually, the system must be carefully watched when starting and the power must be cut off immediately should any repeater "run away" i.e., run as a motor at high speed.

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SECTION IV
INSPECTION

Paragraph
Inspection ---------- 21

21. INSPECTION. - Inspection is made for the purpose of determining the condition of the data transmission system, whether repairs or adjustments are required, and the remedies necessary to insure serviceability and proper functioning. The following list will serve as a guide:

Parts to be inspected	Points to be observed
a. Generating unit.	
(1) General.	(1) Observe general appearance and note whether any parts are damaged, broken or missing. Check for completeness of accessories and tools.
(2) Lubrication.	(2) Check crank case oil level and condition of the oil, oil filter and air filter. Examine grease cups, oil cups and other points of lubrication, checking for presence of proper lubricant and cleanliness. See paragraphs 18, 23, and 26.
(3) Fuel and water.	(3) Check gage fuel level against stick reading. Operation will indicate water level and condition of radiator, hose and connections, circulation and temperature indication. See paragraphs 18 and 25.
(4) Generating unit electrical system.	(4) Check battery for height of water, specific gravity, and rate of charging. Battery case should be unbroken and sealing should be intact. Check fuses, tight connections, spark plugs, distributor and brushes. See paragraphs 14 and 18.

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Parts to be inspected	Points to be observed
(5) Panel board.	(5) Start the engine (disconnected from data transmission system) and note any abnormal indications of panel board instruments. See paragraph 19.
(6) Operation.	(6) Note smoothness of operation, engine speed and absence of smoke.
b. Cable assemblies.	
(1) Mechanical condition.	(1) Observe whether any plugs or receptacles are damaged. Receptacle covers and chains should be intact. Cables should not be frayed or cut.
(2) Electrical condition.	(2) Check cables for continuity and short circuits. Check for tight connections.
c. Boxes.	
(1) Mechanical condition.	(1) Observe whether cases are bent or broken; whether water sealing is broken. Check for missing screws.
(2) Electrical condition.	(2) Check plugs, receptacles and internal connections for continuity and short circuits. Connections should be tight. Check the lighting transformer in the main junction box.
d. Indicators.	
(1) Appearance.	(1) Observe whether cases are bent or broken. Windows and water sealing should be intact. Knobs should be in good condition. Scales and indexes should be clearly legible.
(2) Backlash and binding.	(2) Turn mechanical input shafts and check for backlash and binding. Electrical index should rotate freely.

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INSPECTION

Parts to be inspected	Points to be observed
(3) Electrical condition.	(3) Wiring and connections should be in good condition. See paragraph 23.

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SECTION V

MAINTENANCE AND REPAIR

	Paragraph
Disassembly and assembly	22
Test and adjustment	23

22. DISASSEMBLY AND ASSEMBLY. - a. General. - Disassembly and assembly incident to normal operation are covered in SECTION III. Further disassembly and assembly may be required for cleaning, repair or adjustment. Repairs must be made only by qualified personnel. Repair of the component parts of the data transmission system, M3 which cannot be made with the facilities available will require the return of the part to the base shop or arsenal. Assembly may be made by reversing steps taken in disassembly except where indicated. Parts should be marked to assure alinement on reassembly.

b. Boxes. - Covers may be removed from the various boxes and terminal strips when necessary for examination and checking of connections. Covers must be replaced and properly sealed immediately after completing check. When opening boxes which have been closed for some time, it will often be found that the rubber gasket adheres tightly to the lid. To facilitate breaking this bond, slots have been provided to permit the insertion of a lever. Care must be exercised not to insert the tool far enough to damage the gasket. Care must be taken to avoid nicking the sealing surface of the lid or body, thus spoiling the joint. Replace the gasket if necessary. Markings on leads should be checked against the wiring diagrams to insure proper reassembly.

c. Azimuth or elevation indicators. - (1) To gain access to the terminal block (B136507, Figure 18) remove the cover (A46456). The terminal block is secured to the case by two screws, BCGX3FG.

(2) To gain access to the interior of the case remove the frame (C56986, Figure 15). The windows may then be withdrawn if necessary by removing the retainer (C56987) secured by flathead screws. In reassembly, an authorized sealing compound shall be used to seal the windows.

(3) To remove the mechanism from the case at this point (after removal of frame and disconnecting of necessary leads to terminal block) unscrew first the two nuts (A46449, Section D-D, Figure 18) each secured by a screw (A46450) and washer. Unscrew and withdraw from the case the two adjusting knobs,

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(A46446) and springs (A46447). Remove the packing gland (A46464, Figure 16) and the components. Remove the three bolts (BCAX1CC, Figure 17) and washers and lift the mechanism carefully out of the case.

(4) To remove the coarse repeater from the mechanism withdraw the adapter (A48231B, Figure 15) and securing nut. Remove the scale (B136689), the nut (A46475) and lock screw. Slide the worm gear (B136685) and the two ball bearings off the shaft. Remove the three screws (BCGX3FG). Remove the yoke (B136690). Remove the adapter (A46472). In disengaging the worm gear from the worm (A46469, Figure 16) it may be necessary to withdraw the retainer (A46470) secured by three fillister head screws and two dowels. The worm shaft should be disengaged from the miter gear (A46467) by driving out the securing taper pin. Withdraw the shaft, unscrewing if necessary, to clear the worm gear (B136685).

(5) To remove the fine repeater from the mechanism withdraw the adapter (A48231C, Figure 15) and its securing nut, and the gear (B136686). Remove the yoke (B136690) if this has not already been done for the coarse repeater. Remove adapter (A46472). Withdraw repeater and unscrew the nut (A46475). Remove the lock screw, the retainer (A46473) and the adapter (A46471).

(6) Repeaters requiring repairs involving disassembly should be turned in to a base shop or arsenal.

d. Fuze indicator, M3. - (1) Access to the terminal block and wiring may be obtained by removing the cover (A46456, Figure 21).

(2) To remove the mechanism from the case, unscrew the bolts securing the base (D28865, Figure 20) to the case.

(3) To remove the repeater from the mechanism, withdraw the adapter (A48232A, Figure 20), split washer (A38607) and securing nut (A46804). Remove the index support (A46426). Remove nut (A46233) and lock screw. Draw the miter gear (B136680) and two ball bearings off the shaft. Unscrew the bracket (A46435) and adapter (A46430) and then withdraw the repeater. Remove the adapter (A46436).

(4) To remove the shaft (A46428) remove the retainer (A46434) unscrew the nut (A46433) and headless lock screw, and then push the shaft out at the top. Remove packing gland (A46431).

(5) Repeaters requiring repairs involving disassembly should be turned in at a base shop or arsenal.

e. Generating unit, M3. - The engine and auxiliary equip-

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ment are commercial units. The parts and their functions are familiar to all personnel trained in this work. The generating unit may be disassembled to the extent indicated below:

(1) Disassembly permitted the using arm.

(2) Removal and disassembly of accessories as carburetor, air cleaner, magneto, distributor, generator, starter, fuel pump, governor, radiator.

(3) Disassembly of engine as removal of cylinder head, valves, pistons, rings, connecting rods, crankshaft, oil pan, camshaft, idler shaft, water pump.

(4) Disassembly of generator; control panel, removal of instruments. Disassembly of the instruments themselves is not advised. These should be returned to a base shop or arsenal and new instruments requested.

23. TEST AND ADJUSTMENT. - a. General. - The tests and adjustments described below are in addition to those made as part of normal operation. See SECTION III. The electrical adjustment described below involves adjustment of the repeater to agree with its corresponding transmitter. The mechanical adjustment described below involves adjustment for agreement between the indexes and scales of each unit.

b. Electrical adjustment. - In order that the various corresponding repeaters and transmitters indicate alike, it is necessary that the system be initially synchronized.

(1) This adjustment is ordinarily accomplished at the factory by setting all units on electrical zero when the element of data transmitted is zero. Units of systems so initially adjusted may be interchanged between systems without further readjustment.

(2) Further adjustment in the field should be required only on systems not properly initially set on electrical zero, or on systems which have had one or more synchronous units, or other components affecting the adjustment replaced or disturbed. Any system which appears to require such adjustment a second time should be carefully inspected as soon as possible to determine the cause, as a change or failure in some component is indicated; electrical connections in particular should be carefully checked as angular differences (often multiples of 60°) may be introduced by wrong connections.

(3) There are two methods by which the synchronizing adjustment may be performed. The first is to set all units, both transmitters and repeaters, on electrical zero when the value of the element of data transmitted is zero. The second method

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is to set only one of the two connected units (transmitters or repeaters) in each circuit so the transmitted and received indications are in agreement without regard to electrical zero. The former procedure has the advantage of providing complete interchangeability of units and should be followed when conditions permit; the latter procedure ordinarily requires less time and does not necessitate access to the interior of the director, making it preferable in some cases for field adjustment. Systems adjusted by the second method should be readjusted by the first method as soon as conditions permit. The general method for making electrical zero settings is given in (4) below; procedure for changing the settings or indications on the various parts is in (6) below.

(4) Electrical zero is a standardized reference position of rotor relative to the frame of a synchronous transmitter or repeater; when the rotor of a transmitter occupies that position, the rotors of all repeaters having their terminals connected to the corresponding transmitter terminals will also assume that position. The general procedure is as follows:

(a) Determine the electrical zero of at least one of the repeater units of each transmission circuit by the procedure given in (5) below and adjust the scale to read zero at that position.

(b) Adjust the transmitter unit and its scale to agree with the standardized repeater.

(c) Adjust the scales of the remaining repeater units of the circuit to agree with the standardized repeater and transmitter.

(5) To determine the electrical zero of a single a-c synchronous unit proceed as follows:

(a) Connect the terminals of the unit marked 1, 3, and 5 to one side of a 115-volt, 60-cycle, a-c power supply and the terminals marked 2 and 4 to the other side. When the power circuit is energized, the rotor, if unrestrained, will assume a position very close to that defined as the electrical zero position (within a few tenths of a degree).

(b) Without otherwise disturbing the connections given in (a) above, break the connection to the terminal marked 2, leaving it open. With the power circuit energized, the rotor, if unrestrained, will assume either the electrical zero position, or a position 180° therefrom. The procedure in (a) above will distinguish between these two positions.

(c) When adjusting the dial or scale at the electrical

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zero position, be sure the rotor is not displaced from its equilibrium position by frictional forces.

(d) This method is applicable equally well to transmitters and repeaters. However, it is seldom that transmitters with unrestrained rotors are encountered, and for that reason the method of adjustment described in (4) above is necessary.

(6) The procedure for changing the electrical indications of the indicators is described below. The adjustment is made with the system connected up and the power on. When shifting of a repeater dial or index is necessary, observe the precaution that the unit does not "run away", that is, run at a high speed as a motor during this operation. After adjustment is completed, check carefully for mechanical freedom, with power off, first by rotating slowly, holding lightly by the fingers, then by spinning rapidly, and as a further check by displacing the index a small amount (say 1^{o}) in one direction, than in the other, and observing that the return in both cases is to the same indication. Dials, scales, and indexes are of thin metal and must be handled carefully.

(a) Azimuth or elevation indicator, M3. - Adjustment of the repeaters should be tried first by turning the knobs provided for rotating the coarse and fine repeaters through an angle of about 30^{o} each. Shifting of the scales should not be required but, if necessary, loosen the three screws clamping the dial or index to permit turning by hand for a coarse adjustment. The knobs are then used to effect close adjustment. The motion of the knobs has been purposely made stiff to avoid accidental shifting.

(b) Fuze indicator, M3. - Adjustment of the fuze indicator follows that of the azimuth or elevation indicator, M3, except that only one repeater is used.

c. Initial mechanical adjustment. - Initial mechanical adjustment of the indicators is made on the gun mounts. The slip coupling connections between indicators and the mechanisms associated with the movement of the gun permit orientation of the indicators with the gun.

d. Emergency trouble-shooting. - The possible troubles encountered with the transmission system may be divided into two general classes: First, troubles arising in a system initially synchronized and in which there has been no change in the component parts; second, troubles experienced when assembling a new system or when replacing one or more of the component parts. Troubles encountered with systems of the first-mentioned

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classification are not likely to include incorrect electrical connections; in systems of the second classification, almost any of the possible troubles may be encountered. When attempting to correct trouble that may arise in the field, general procedure followed will ordinarily be to locate the fault, to determine its nature by the characteristics observed, and to take the most rapid and expedient means available to restore the system to operation, without regard to maintaining the wiring in accordance with standard diagrams nor to retaining interchangeability. Systems so modified, however, should be restored to agree with the standard wiring diagrams as soon as circumstances permit. Units not already set on electrical zero should be so adjusted as soon as possible. On repeaters with accessible dials or indexes, a simple and often effective test is to displace the dial or index a small amount (say 1^{o}) first in one direction then in the other. If the indication returned to in both cases is not the same, mechanical difficulty or a deficiency of torque is indicated. Some of the more common troubles encountered, probable causes, and corrective measures are outlined below. In most cases the corrective measures are temporary in nature, and demand a thorough recheck of connections to insure accordance with the wiring diagram as soon as possible.

(1) Constant error between transmitter and one or more repeaters, direction of rotation being correct. - The system may be improperly synchronized. Follow the procedure pertaining to the device in which the trouble is experienced.

(2) One or more repeaters rotate in opposite direction from connected transmitter. - The direction of rotation of a repeater may be reversed by interchanging any two of the armature connections (1, 2, and 3). If the electrical zero indication is correct, it may be retained by confining the interchange to terminals 1 and 3, the other possible combinations rotate the electrical zero position by $\pm$ 120^{o}. This change may be made anywhere between the transmitter and the repeater. In the case of the azimuth and elevation transmitters, which have multiple repeaters, reversal at the transmitter terminals (in the main junction box) will reverse all four repeaters; reversal at the repeater terminals (in the gun junction box, receptacle box, or distribution box) will reverse only the single repeater involved without affecting the directions of the others.

(3) One or more repeaters fall out of synchronism during part of revolution. - This condition is characterized by a jumpy motion of the repeater dials while the transmitter rotates at

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a substantially uniform rate, the irregularily appearing at approximately the same point on the dial. Trouble of this description may arise at either the transmitter or the repeater and the cause may be either electrical or mechanical.

(a) When due to trouble at a repeater, all other repeaters connected in parallel will be affected somewhat, but the faulty repeater will usually experience the greatest effect. When the faulty repeater is disconnected, by removing the plug (cut off power while disconnecting) at the receptacle box, main junction box, or (for fuse indicators only) gun junction box, as convenient, the balance of the system will function correctly. If the first attempt is not successful the faulty unit may be reached by the process of elimination.

(b) When due to trouble at a transmitter, all repeaters will be affected alike. It will not be possible to eliminate it by disconnecting repeaters.

(c) Electrical troubles of this type may be found in either transmitter or repeater and usually consist of a defect in a brush, brush rigging, or slip ring which will cause a circuit interruption at a specific angular position. The interruption may be in either the field or armature depending on the manufacturer's practice. The location may be found by the use of the ohmmeter or voltmeter and ammeter.

(d) Mechanical troubles of this type are ordinarily encountered only at the repeaters. Similar faults may occur at the transmitters also but will not cause discrepancies between transmitted and received data; they may, however, cause a jumpy motion of the transmitter which may be accentuated at the repeaters; in the director they may also cause errors in computation which may be detected by accuracy tests. The general nature of the fault is that some moving part is binding on some stationary part. Binding of the dial or index at some point is the most likely cause. A similar fault, called a "high spot", sometimes occurs in a ball bearing.

(e) When trouble of this kind is encountered, locate and analyze the trouble in accordance with the foregoing, and correct it if possible. If impossible, take such steps as will render the system most useful, considering the time and facilities available for correction. Faults within synchronous transmitters and repeaters require replacement of the unit, an operation which requires considerable time. To replace a unit in a director, a dry closed room free from floating particles of dust is required. If mechanical trouble in the azimuth, ele-

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vation, or fuse indicator is detected, the dials should be carefully checked for clearance. There may be sufficient play between dial and adapter hub to shift the dial slightly. When the fault is likely to injure the unit itself or other components (as by overheating due to excessive displacement from the synchronous position) or to affect the accuracy of other components, the unit should be disconnected immediately so as to least impair the remainder of the system.

(4) One or more repeaters fail to synchronize, remaining inoperative. - This condition usually indicates an open circuit or short circuit in one of the transmitters, repeaters, or connecting cable. It may also occur intermittently due to a cable fault which occurs through a small region of elevation or azimuth.

(a) Intermittent faults of this character are sometimes difficult to locate, as they seldom occur consistently. Therefore, when a fault of this nature is noticed but disappears before being corrected, a complete record should be made of the occurrence to assist in locating the trouble should it recur later.

(b) Faults of this nature may often be located by observing the characteristics of the fault and using the ohmmeter, voltmeter, and ammeter (see (3) above).

(c) Individual cables may be checked readily with the ohmmeter, a very low resistance reading indicating continuity. The cable is disconnected at both ends which are placed conveniently close together. The ohmmeter then is used to indicate: Continuity of the conductor from the terminating device at one end to the corresponding device at the other end; lack of continuity between one conductor and all remaining conductors in the cable.

(d) When once a faulty cable is detected and located, the appropriate action must be taken. If the fault is in a portable cable and all the cables furnished are not in use, substitute another cable for the faulty one. If the foregoing procedure cannot be followed, substitute a spare conductor in the cable, if available, for the faulty conductor. It may be possible to disconnect the faulty conductor and substitute an external wire, improvised for the purpose. Ordinarily, No. 14 rubber insulated wire, commonly used for house wiring, may be employed satisfactorily. A ground return should never be used in place of one of the conductors since ground resistance is variable, causing circuit unbalance, and extraneous voltages may be picked up due

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to ground currents.

(5) One or more repeaters lag behind the transmitter in either direction of rotation. - This condition indicates excessive mechanical load, or insufficient torque at the repeater. The amount of lag will be found to vary with the speed or acceleration, and may become zero when at rest.

(a) The generators' voltage or the voltage at the gun indicators, or both, may be incorrect. An open circuit in the field circuit of a transmitter or repeater (but not both) will also cause great reduction of torque, the repeater then assuming either of two positions 180° apart with equal facility.

(b) An excessive mechanical load such as a tight bearing or binding dial will cause this condition.

(6) One or more repeaters remain stationary for a time, then suddenly rotate 180° and again remain stationary. - This condition usually indicates a short circuit between two armature (1, 2, 3) leads and will be accompanied by an abnormally loud hum at certain angular positions. Power must be removed from the system immediately when this fault is noticed. This condition is also accompanied by a reacting torque on the transmitter which may cause injury to delicate mechanisms. Procedure of location is as given in (3) above.

(7) Repeater fails to come to rest, but oscillates about its central position. - This indicates a defective damping mechanism on the repeater. In the case of multiple repeaters, all repeaters will usually be affected, but the defective repeater may oscillate through a greater angle.

(a) If the oscillation is not large, it may be possible to retain the unit in service, following the average rather than the instantaneous motion with the follow-the-pointer drive.

(b) When the oscillation is too large for this, or when it interferes with the use of other connected repeaters, the unit must be disconnected as unserviceable.

(c) In either case this fault requires a replacement of the repeater, an operation which is to be performed only by trained ordnance personnel.

(d) When operating with a defective damping device, the repeater must be watched closely and, if it starts to run as a motor, power must be removed from the system at once.

e. Adjustment of generating unit. - (1) Governor. - (a) The governor is adjusted at the factory and should require little attention. Normal engine speed is 1,200 rpm, which corresponds to 60-cycle alternating current for which the system is designed.

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The system will operate satisfactorily when the frequency is between the limits of 55 to 65 cycles, or 1,100 to 1,300 rpm. The speed should be measured operating under full-load conditions at normal voltage after the unit has been running at least 15 minutes to insure stability. Measurements are conveniently made on the shaft extending from the oil-pump housing, using the revolution counter furnished with the unit and an accurate watch or time interval recorder. If the speed is between 1,125 and 1,275 rpm no change is necessary. If beyond these limits, the speed should be adjusted using the screw provided.

(b) There should be little lost motion between the governor arm and the carburetor lever and these parts should operate freely without binding. These parts must not be allowed to rub against the removable side cover of the generating unit. No adjustment of the governor should be attempted if the speed does not remain constant but surges or "hunts". Such a condition may be caused by lost motion or binding in the governor mechanism, by faulty ignition or carburetion, or by an obstruction in the fuel supply. If the rod connecting the carburetor lever with the governor arm has been disconnected for any reason, be sure that the rod holds the carburetor-butterfly valve wide open when governor lever is in its normal position with engine stopped.

(2) Oil pressure. - The oil pressure should be between the limits of 20 to 26 pounds per square inch under full-load conditions. As the parts become worn in service, the pressure will tend to approach the lower value; this indicates that more, not less, oil is flowing and no adjustment should be made. The engine must, however, never be operated with a pressure of less than 15 pounds per square inch. Adjustment is by means of the large screw at the base of the oil-pump housing. Turn the screw clockwise to increase pressure. Always loosen the lock nut on the screw before adjusting, and tighten when adjustment is completed.

(3) Automatic choke. - The automatic choke is of rugged construction and should require little attention. When the engine is cold (at normal ambient temperature), the thermal arm should be at its extreme counterclockwise position, the butterfly valve should be at its extreme clockwise (closed) position, and there should be free travel between open and closed positions. The adjustment lock screw should be set for about 5/8 inch travel of thermal element when the choke element has been disconnected from the engine and the thermal element has been unhooked from

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the adjustment stop. Be sure to return the thermal element to its original position when the adjustment is completed. Should excessive choking occur, it may be found that the outer end of the thermal element has made one full turn and again becomes engaged on the adjustment stop. This condition will be readily detected by the above check, and necessitates that the adjustment stop be slightly bent inward so the thermal element cannot get under it.

(4) Breaker points. - Breaker points that show a grayish color, are free from pits, and have a gap of 0.020 ± 0.002 inch, as checked by a wire feeler gage, require no adjustment. Should they require adjustment, it will also be necessary that they be refaced by means of an oilstone and realined so as to present smooth faces toward each other with full contact.

(5) Clearances. -

TABLE OF CLEARANCES

	Min.	Max.
Valve tappet clearance, intake (Hot)	.006	
Valve tappet clearance, exhaust (Hot)	.006	
Valve seat width, intake	.125	
Valve seat width, exhaust	.125	
Valve stem clearance in guide, exh. & int.	.001	.0015
Push rod or tappet clearance in guide	.0008	.001
Idler bearing clearance	.001	.0015
Cam bearing clearance	.0015	.0025
Crankshaft main bearing clearance	.002	.0025
Crankshaft end thrust	.002	.004
Bell housing on chamfer	.012	.025
Connecting rod bearing	.001	.0015
Connecting rod bearing, end clearance	.005	.010
Accessory drive bearing clearance	.0015	.002
Accessory drive bearing, end clearance	.001	.002
Gear cover clearance around crankshaft	.008	.015
Oil pan clearance around crankshaft	.008	.015
Accessory drive gear backlash	.002	.003
Crankshaft gear backlash	.000	.002
Idler gear backlash	.001	.002
Oil pump gear backlash	.008	.010
Piston clearance, cast iron	.002	.0025
Piston ring clearance in groove	.001	.0025
Piston ring gap	.015	.020
Piston pin clearance	.005	

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SECTION VI

CARE AND PRESERVATION

	Paragraph
General precaution	24
Care in handling	25
Lubrication	26

24. GENERAL PRECAUTION. - The other end of the portable cable connected to the generating unit must never be plugged into any other receptacle except the one on the main junction box designated "Power Plant" and painted yellow. This power cable must never be connected to a director, height finder, or receptacle on a gun mount. Failure to observe this precaution will result in burning out the synchronous transmitters and repeaters in the director, height finder, or on-carriage indicators and may otherwise seriously damage the mechanisms in these units.

25. CARE IN HANDLING. - The data transmission system is designed to require a minimum of attention and care beyond routine precautions to prevent damage to its component parts. Periodic examination of all the various units should be made to insure that the system will continue in satisfactory operation.

a. Cables. - (1) The 20-conductor portable cable supplied with this system must not be subjected to repeated kinking or twisting. The importance of giving the cable the best possible care cannot be overemphasized. Avoid bending the cable on a short radius, or allowing it to chafe against any moving object. Do not allow heavy vehicles to run over the cables.

(2) Do not allow dirt to accumulate in the plugs or receptacles. When the cables are not connected, all plugs and receptacles must be kept closed with the covers provided so as to exclude dirt and moisture. When the cables are connected, the mating plugs and receptacles must be mechanically secured together by the round nuts provided.

(3) Oil and grease are detrimental to rubber and care should therefore be exercised to see that the cables are kept free of these materials. Store cables in a cool dark place, to protect the rubber. Cables not in use should be stored on the reels provided.

(4) In case it is necessary to tape the end of any of the conductors of the flexible cables, use rubber tape only.

(5) Cables should be tested periodically for open and short circuits.

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b. Generating unit. - The engine of the generating unit is similar to common types of automobile engines and requires similar care.

(1) Never run a unit indoors without means for conducting the exhaust fumes to the outside.

(2) Never fill the gasoline tank with the unit running.

(3) Exercise extreme care to avoid spilling gasoline, especially when operating within a building.

(4) Keep the sediment trap and filter screen in the gasoline line clean.

(5) If insufficient fuel is obtained after cleaning the trap and screen, clean the float valve, the passage from the float chamber or bowl to the venturi, and the needle valve. These are reached by removing cap screws in the side of the carburetor.

(6) Keep the cooling system properly filled with water or antifreeze mixture of the proper concentration. Avoid the use of antifreeze mixture when not needed and of a greater percentage of alcohol than required. Occasionally flush out the cooling system with clean water.

(7) Clean the storage battery terminals occasionally and coat lightly with grease.

(8) Maintain the level of the water in the storage battery well above the tops of the plates. After the battery has been placed in service add only distilled water to the cells. See instructions included with battery.

(9) Clean the air cleaner at least every time the crankcase oil is changed; under severe dust conditions it must be cleaned every day. To clean Air Maze cleaners, swish up and down and sideways in a pan of waste crankcase oil, shake off surplus, and replace. Gasoline must not be used under any circumstances.

(10) Use the two generating units alternately to insure equal wear on each.

(11) Commutators in proper operating condition should present a polished black appearance. If a commutator becomes dirty it may be cleaned with coarse cloth or, if necessary, with No. 00 flint paper. Never use emery paper or cloth on the commutator nor allow oil or grease to come in contact therewith.

(12) Brushes should be replaced when badly worn. They should seat squarely on the commutators.

(13) Spark plugs should be cleaned and set occasionally.

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c. Synchronous repeaters. - Should any repeater start to "run away", that is, run as a motor at a high rate of speed, cut off the power immediately.

26. LUBRICATION. -

Part	Frequency	Lubricant	Quantity and application
Crankcase	30 hours, operation.	Engine Oil[1]	Fill through breather tube as required to 4/4 mark on bayonet gage.
Generator	100 hours, operation.	Cup grease[3]	One turn of grease cup cap each bearing (front bearing is greased through 1/8 inch pipe between engine and generator; rear bearing through hole in bearing cap.) Keep grease cup filled.
Water pump	100 hours, operation.	Waterproof grease[2]	One turn of grease cup cap. Keep grease cup filled.
Distributor	100 hours, operation.	Engine oil[1]	Few drops in oiler.
Fan	100 hours, operation.	Engine oil[1]	Remove plug in hub. Fill until oil drips from shaft.
Starter	100 hours, operation.	Engine oil[1]	Few drops in oil hole.
Charging generator	100 hours, operation.	Engine oil[1]	8 to 10 drops in oil cup at each end.
Breaker mechanism	Semi-annually	Cup grease[3]	Wipe breaker cam lightly with grease.
		Engine oil[1]	One drop on breaker cam pivot pin.
Data indicators	Occasionally	Lubricating oil[4]	Few drops on gear trains and points where shafts enter housings. (Repeaters not to be lubricated.)

See footnotes at end of chart.

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26. LUBRICATION (Continued)

Part	Frequency	Lubricant	Quantity and application
Governor linkage Commutators and slip rings.	Occasionally Do not lubricate under any circumstances.	Engine oil[1]	Few drops on joints.
Automatic choke	Do not lubricate under any circumstances.		
All radial ball bearings, journal bearings and all other sliding surfaces of the indicators.	When assembling	Grease, special, low temperature	Apply a thin coat upon assembly

[1]OIL, engine, SAE 30 (Navy Symbol 1065) for prevailing temperature above 32° F. and OIL, engine, SAE 10 (Navy Symbol 1042) for prevailing temperature between 32° F. and 0° F. Below 0° F. dilute the crankcase oil with 10% gasoline or kerosene, or 15% Diesel fuel.

Care must be taken to maintain the diluent at this ratio since it will be partially driven off during operation. In extremely low temperatures, if circumstances permit, drain the crankcase while the unit is still warm and then heat the oil before replacing, to a temperature where the hand can just be inserted without burning. Change oil every 30 hours of operation.

[2]Waterproof grease No. 4.

[3]Chassis grease No. 1.

[4]OIL, lubricating, for aircraft instruments and machine guns.

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SECTION VII

REFERENCES

	Paragraph
Standard nomenclature lists	27
Technical manuals	28

27. STANDARD NOMENCLATURE LISTS:

System, data transmission, M3	SNL F-178
Current Standard Nomenclature Lists are as tabulated here. An up-to-date list of SNL'S is maintained as the "Ordnance Publications for Supply Index"	(OPSI)

28. TECHNICAL MANUALS:

Artillery, antiaircraft, 3-inch gun materiel (mobile)	TM 9-360
Cleaning and preserving materials	TM 9-850
Ordnance maintenance - Height finder, M1	TM 9-1623
Ordnance maintenance - Director, M3	TM 9-1650
Ordnance maintenance - Director, M4	TM 9-1655
Instruction guide - Height finder, M1	TM 9-2623
Instruction guide - Director, M4	TM 9-2655

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ORDNANCE MAINTENANCE - DATA TRANSMISSION SYSTEM, M3

INDEX

	Paragraphs	Pages
ADJUSTMENT	23	58-66
ANTIFREEZE SOLUTION FOR GASOLINE ENGINE	18	51
AUTOMATIC CHOKE, ADJUSTMENT	23	65-66
AUTOTRANSFORMER, DESCRIPTION	14	49
BATTERY	18	51
BOX, DISTRIBUTION, DESCRIPTION	9	10, 15
BOX, GUN JUNCTION, DESCRIPTION	10	15
BOX, MAIN JUNCTION, DESCRIPTION	7	10
BOX, RECEPTACLE 18- AND 19-POLE, DESCRIPTION	8	10
BOXES		
Disassembly and assembly	22	56
Inspection	21	54
BREAKER POINTS, ADJUSTMENT	23	66
CABLE ASSEMBLIES		
Care and preservation	25	67
Description	13	31, 37
Inspection	21	54
CARE AND PRESERVATION	24-26	67-70
Care in handling	25	67-69
General precaution	24	67
Lubrication	26	69-70
CLEARANCES, TABLE	23	66
COMMERCIAL POWER SUPPLY, OPERATION FROM	20	52
COOLING SYSTEM OF GASOLINE ENGINE	14	48
DIRECTORS, A.A., M3 AND M4, DATA TRANSMISSION SYSTEM	4	3
DISASSEMBLY AND ASSEMBLY	22	56-58
Boxes	22	56
Indicator, fuze, M3	22	57
Indicators, azimuth and elevation	22	56-57
Unit, generating, M3	22	57-58
FUEL FOR GASOLINE ENGINE	14, 18, 21	48, 51, 53
GASOLINE ENGINE, SPECIFICATIONS	14	46-48
GENERATOR, DESCRIPTION	14	37, 46
GOVERNOR OF GASOLINE ENGINE	14	48

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INDEX

	Paragraphs	Pages
INDICATORS, AZIMUTH AND ELEVATION, M3		
Disassembly and assembly	22	56-57
Electrical adjustment	23	60
General description	11	15, 25
Inspection	21	54-55
INDICATOR, FUZE, M3		
Disassembly and assembly	22	57
Electrical adjustment	23	60
General description	12	25, 31
Inspection	21	54-55
INSPECTION	21	53-55
Boxes	21	54
Cable assemblies	21	54
Generating unit	21	53-54
Indicators	21	54-55
LUBRICATION		
Chart	26	69-70
General	21	53
Generating unit	18	50-51
MAINTENANCE AND REPAIR	22-23	56-66
Disassembly and assembly	22	56-58
Test and adjustment	23	58-66
MANUALS, TECHNICAL	28	71
ON-CARRIAGE UNITS	5	3
OPERATION	15-20	50-52
Connecting cables	17	50
Operation from commercial power supply	20	52
Starting and stopping	19	52
Units, arrangement of	16	50
Unit, generating	18	50-52
PANEL BOARD	14, 21	48-49, 54
REFERENCES	27-38	71
Standard Nomenclature Lists	27	71
Technical Manuals	28	71
REPEATERS, SYNCHRONOUS		
"Coarse" repeater	11	15, 25
Description	6	5-10
Electrical adjustment	23	58-60
"Fine" repeater	11	15, 25
SELF-SYNCHRONOUS SYSTEM, DEFINITION	6	7

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	Paragraphs	Pages
SETTER, FUZE	12	25
STANDARD NOMENCLATURE LISTS	27	71
STARTING AND STOPPING	19	52
SYNCHRONIZING ADJUSTMENT	23	58-60
SYSTEM, DATA TRANSMISSION, M3		
Components	5	3-5
Electrical adjustment	23	58-60
General description	4	3
Mechanical adjustment	23	60
SYSTEM, DATA TRANSMISSION, T8E3	4	3
TEST AND ADJUSTMENT	23	58-66
Adjustment of generating unit	23	64-66
Electrical adjustment	23	58-60
Emergency trouble-shooting	23	60-64
Initial mechanical adjustment	23	60
TIME DELAY RELAY, DESCRIPTION	14	49
TRANSMITTERS, SYNCHRONOUS		
Description	6	5-10
Electrical adjustment	23	58-60
TROUBLE SHOOTING	23	60-64
UNIT, GENERATING, M3		
Adjustment	23	64-66
Care and preservation	25	68
Disassembly and assembly	22	57-58
General description	14	37, 46
Inspection	21	53-54
Operation	18	50-52

(A.G. 062.11 (12-3-41).)
BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

Official:
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The Adjutant General.

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